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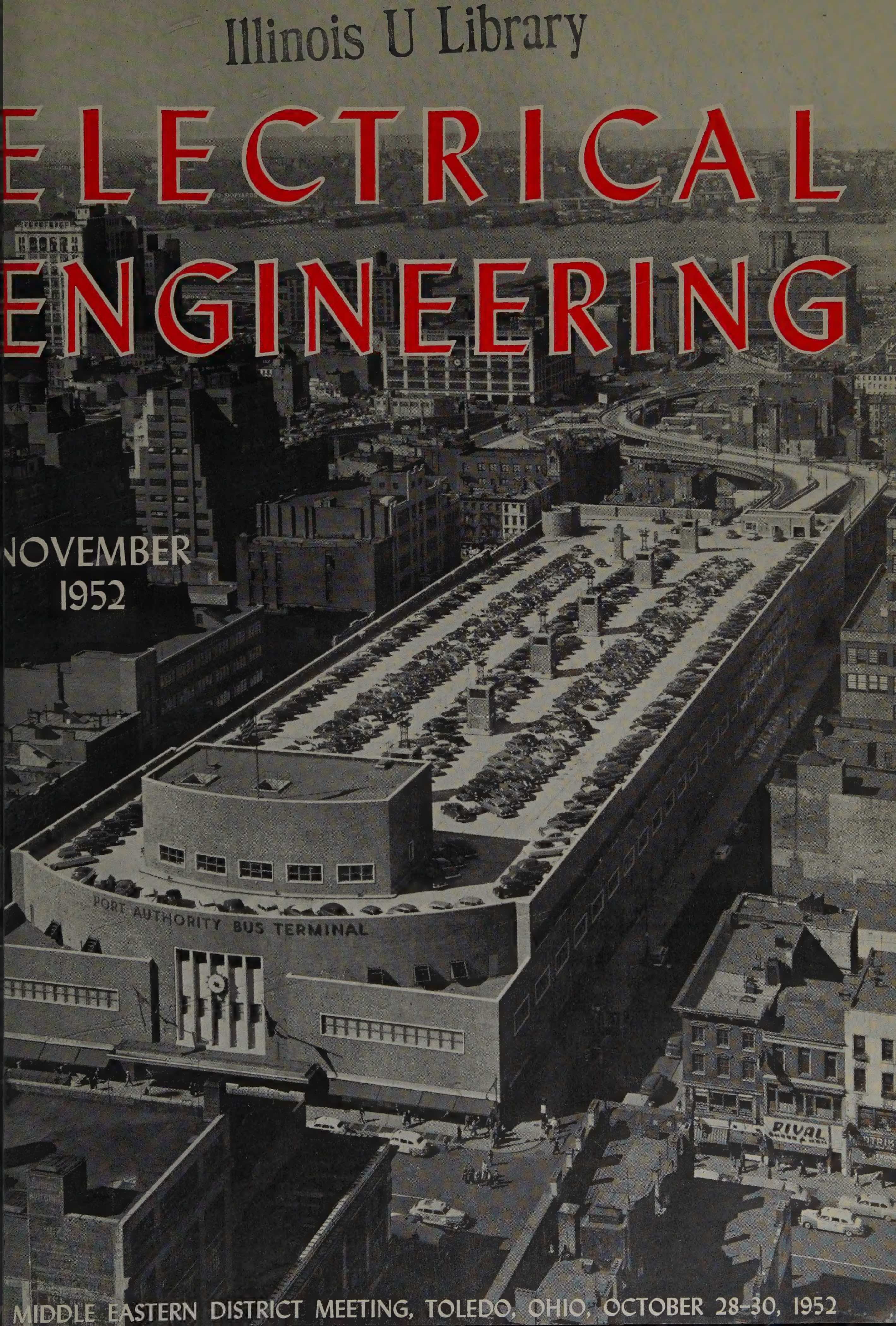
ELECTRICAL ENGINEERING

NOVEMBER
1952



MIDDLE EASTERN DISTRICT MEETING, TOLEDO, OHIO, OCTOBER 28–30, 1952

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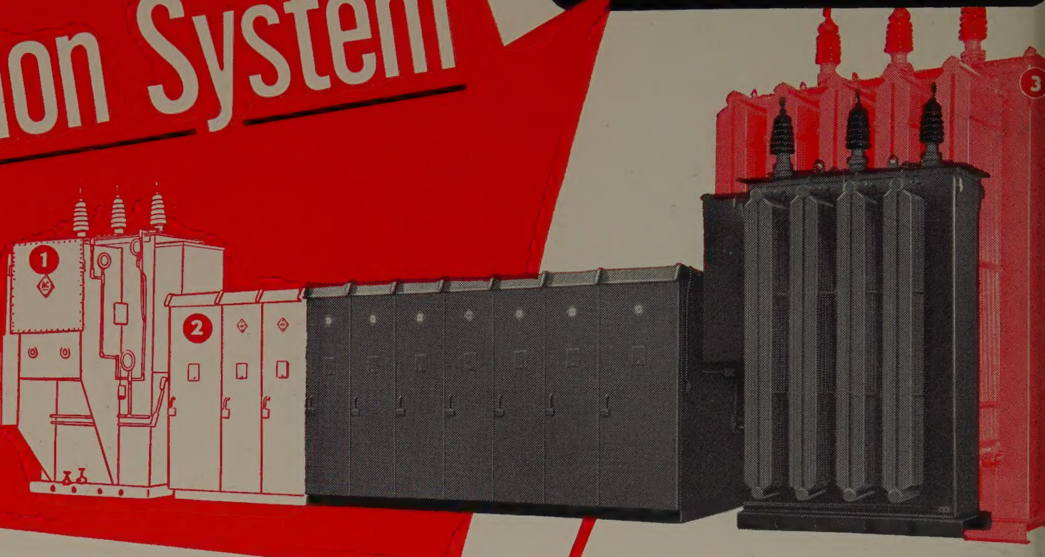

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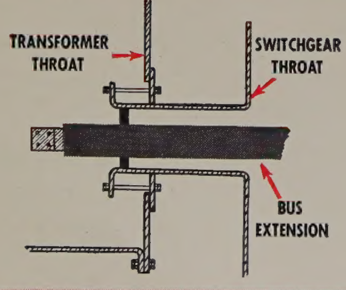

1. DOUBLE ENDING is easy because throat openings of transformer and switchgear are the same height. Bus connectors and throat are flexible, permit realistic tolerances in base construction.

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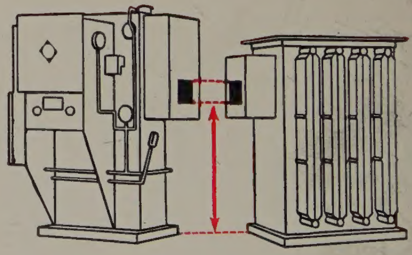

3. A HIGHER CAPACITY TRANSFORMER — within the limits of breaker size and bus capacity — can replace the installed transformer easily and simply in the field.

ELECTRICAL ENGINEERING

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1952

The Cover: View of the New York Port Authority Bus Terminal in New York City. The electric systems of the bus terminal, largest in the world, are described in the article on pages 979–84 of this issue.

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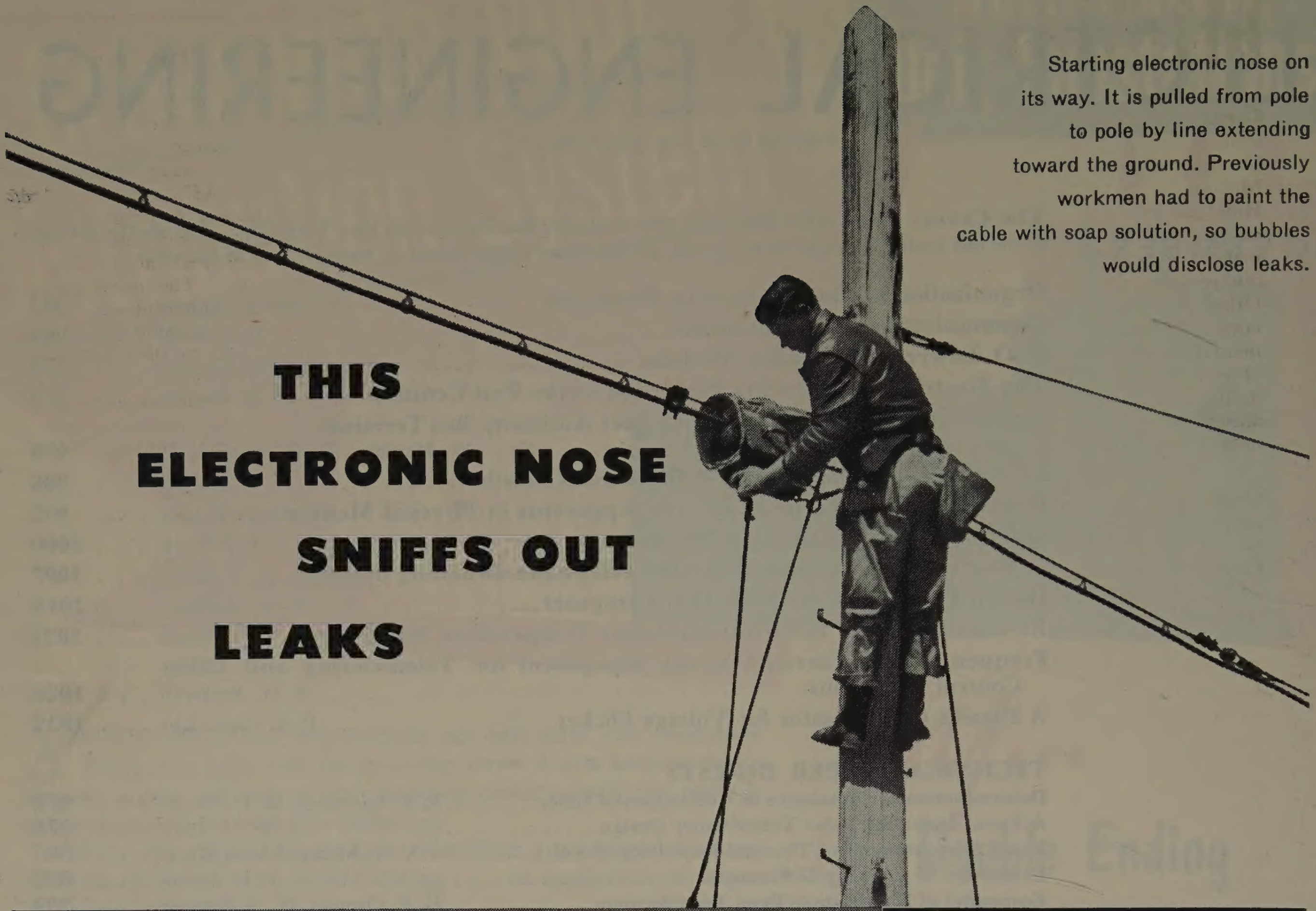
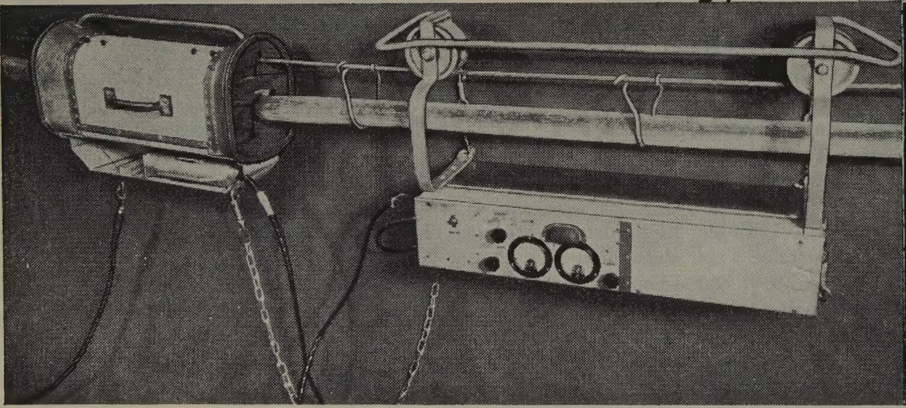
THIS ELECTRONIC NOSE SNIFFS OUT LEAKS



Starting electronic nose on its way. It is pulled from pole to pole by line extending toward the ground. Previously workmen had to paint the cable with soap solution, so bubbles would disclose leaks.



For test, the cable is cleared of protective nitrogen or air, and filled with Freon gas. Case at left collects escaping gas which operates Freon-sensitive detector underneath. At points where Freon escapes through sheath cracks, the box at right—a combined control unit and power supply—rings a bell. Workmen mark the point of leak for later repair.

After years of buffeting by the wind, even tough telephone cable sometimes shows its age. Here and there the lead sheath may crack from fatigue or wear through at support points. Before moisture can enter to damage vital insulation, leaks must be located and sealed.

To speed detection, Bell Laboratories scientists constructed an electronic nose which *sniffs* out the leaks. Using an electrically operated element developed by the General Electric Company, the device detects leaks of as little as 1/100 cubic foot per day. Sheath inspection can be stepped up to 120 feet per minute.

Thus Bell scientists add findings in other fields to their own original research in ways to make your telephone system serve you better. On the other hand their discoveries are often used by other industries. Sharing of scientific information adds greatly to the over-all scientific and technological strength of America.

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HIGHLIGHTS . . . .

Coming Meetings. Some 70 technical sessions and conferences already are planned for this year's Winter General Meeting in New York City in January. Hotel rooms should be reserved as soon as possible, and it is not too early to make reservations for the ever-popular dinner-dance and smoker (*pages 1036–7*). Other coming meetings include the fifth annual Conference on Electronic Instrumentation and Nucleonics in Medicine (*page 1037*), the AIEE Textile Conference in Raleigh, N. C. (*pages 1042–3*), and the annual joint Computer Conference to be held in New York in December (*page 1043*).

Centennial of Engineering. An estimated 27,000 engineers from all branches of the profession attended the recent Centennial of Engineering in Chicago. AIEE participation included five sessions (*pages 1038–40*).

Faraday Medalist. An American, E. O. Lawrence, was this year's recipient of the Faraday Medal, annual award of the British Institution of Electrical Engineers. The presentation was made by the Institution's President, Sir John Hacking, during the Centennial of Engineering (*pages 970–1*).

Development of Electronics. A comparative newcomer to the field of engineering, the electronics industry has reached the status of an essential element in the nation's well-being and progress. This article traces the industry's development (*pages 986–91*).

Communications and Electronics. The conversion of the United States during the past 30 years from a primarily agricultural people to an industrial people has brought about the need for developing a closely knit national business pattern. It is through the communications networks provided by the dynamic communications and electronics industries that an integrated business and industrial community has been made possible (*pages 965–9*).

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Organization of the Engineering Profession. AIEE President Quarles, in an address at a Centennial of Engineering luncheon, considers the past and future of engineering organization (*pages 963–4*).

100 Years of Engineering. As his contribution to a Centennial of Engineering Symposium on the Role of the Organized Profession, Vice-President Hooven discusses the electrical engineering profession during the past century. He points out that the AIEE has taken a major part in the development of the art and thus "in the development of the kind of civilization that holds the greatest hope for mankind" (*pages 973–7*).

New Relay for Telephone Switching. This new wire-spring general-purpose relay will provide important economic advantages such as lower manufacturing costs and reduced switching system costs as less equipment and power are required (*pages 1007–12*).

D-C Adjustable-Voltage Drives for Multisection Machines. The advantages of various types of packaged drives, such as the Ward Leonard and electronic drives, are presented. These drives provide a wide speed range and close co-ordination between sections resulting in greater system flexibility (*pages 1000–05*).

New York Port Authority Bus Terminal. The electric system is required to meet the diversified needs of the various functions of the building as a combined transportation terminal, shopping center, parking area, and office building. The system's most outstanding features are described briefly (*pages 979–84*).

Frequency-Shift Carrier-Current Equipment for Controls. As by-products of the improved frequency-shift transmitter and receiver demodulator discussed here, have come applications to form a new type of channel for transferred tripping, a new method of transmitting load control signals, and a most reliable channel for supervisory-control functions (*pages 1026–31*).

Electric Apparatus in Physical Medicine. The American Medical Association Council on Physical Medicine and Rehabilitation arranges for the testing of apparatus utilizing physical, as opposed to chemical, agents in the diagnosis and treatment of illness and publishes its findings at approximately yearly intervals. Recurrent unsuccessful ideas are stressed, along with the pointing up of fruitful lines for future research (*pages 993–8*).

Bimonthly Publications

The first issues of the new bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, have been released. Superseding the AIEE *Proceedings*, these publications contain the formally reviewed and approved numbered papers (exclusive of ACO's) presented at General and District Meetings. The publications are on an annual subscription basis. In consideration of payment of dues, members may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Temperature Standards for Electrical Insulation. The present standards are examined and several changes are proposed to facilitate the realistic evaluation of current insulating materials and systems (*pages 1021–3*).

Passive Compensator for Voltage Flicker. This device is a low-voltage autotransformer. It is simple, compact, inexpensive, and requires little maintenance (*pages 1032–5*).

ERA 1101 Computer. This is a single address binary-system parallel computer with a 400,000-bit magnetic drum memory. It has a 24-binary-digit word length, equivalent to seven decimal digits plus sign (*pages 1015–18*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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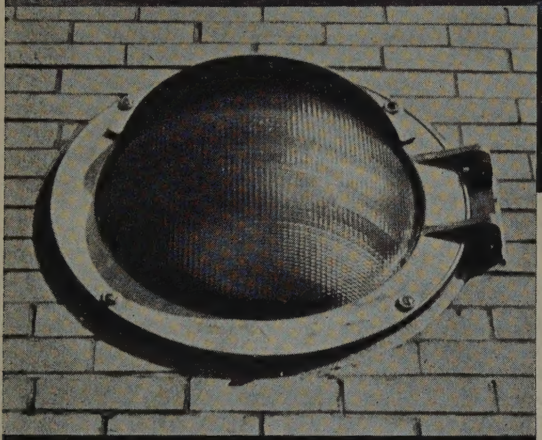
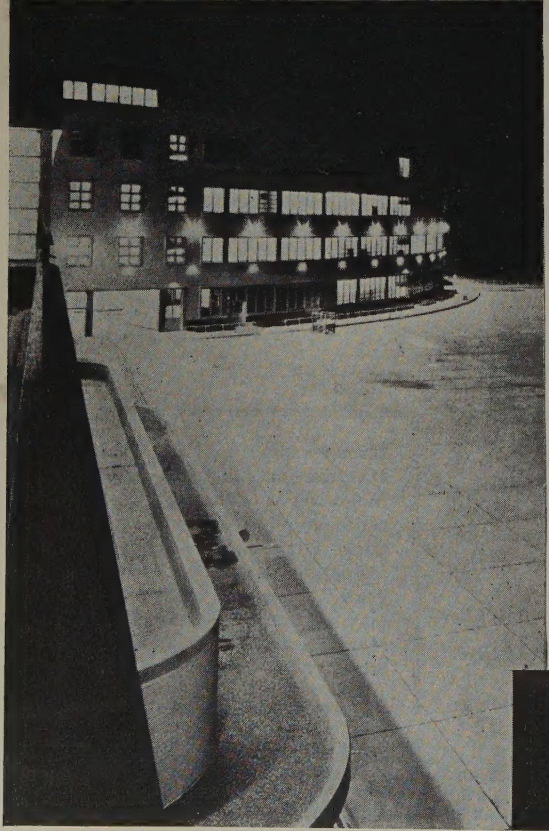


The new Greater Pittsburgh Airport is the most modern airplane Terminal in the world. It is a tribute that Holophane REFRACTOLENS units have been used to light the airport's loading space. These units recessed at two levels in the face of the building follow modern trends in lighting. They produce remarkably effective lighting with five footcandles across the walkways and out to the stairs for boarding planes, 60 feet from the building. Two sizes of REFRACTOLENS units, equipped with visors, were used: lower units, 300 watts each; upper units, 750 watts . . . One more significant result of Holophane research and prismatic light control . . . Architects and engineers are invited to consult Holophane Engineering Service.



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Organization of the Engineering Profession

D. A. QUARLES
PRESIDENT AIEE

THE OCCASION OF the Centennial of the organization of the first civil engineering society in the United States is an appropriate time to pause and reflect on the first 100 years of engineering organization history, and to consider our future course. From the very small beginning in 1852, professional engineering has become a major factor in American life, with an enrollment in professional engineering societies numbered in the hundreds of thousands. Instead of the one engineering society organized at that time, we have at least a score of comparable national societies today, and many more that might lay claim to such a title. In our own field of electrical engineering, which branched off some 68 years ago with the formation of the AIEE, there are today at least two or three other national engineering societies in the field, and this in spite of the fact that our own Institute is organized into some five technical divisions, and these in turn into some 40 technical committee subdivisions which cover substantially the whole gamut of the electrical engineering profession, from power and its industrial applications to communications, electronics, and nucleonics. There are today some 44,000 full-fledged members of AIEE, and some 25,000 or 30,000 members of the Institute of Radio Engineers (IRE), our largest sister society in the electrical field, organized 40 years ago. To cope with the very great expansion in scope of radio engineering, the IRE has now found it necessary to organize into some 17 technical groups.

Since the organization of the American Society of Civil Engineers 100 years ago, professional engineering has assumed a major role in American life. The goal now to be attained is the closer organization of the entire engineering profession.

It is not a wide play on the imagination to look forward to the continuation of this technological trend and to expect that as each page of technical history is turned, new branches of technology will come into being, bringing with them the new demands for technical fraternities to meet the needs and satisfy the interests of the new groups of specialists.

While it seems quite obvious what the trend of technology will be, it is not so obvious as to what would be the best organization of the profession to meet the situation as it unfolds. It is quite obvious, for example, that over and above the technical interests of specialized groups, there are larger so-called professional interests that are common to all groups. I believe we can get almost universal agreement on the proposition that the profession needs some organization to deal with this common professional interest, as well as perhaps the many organizations to deal with the specialized technical interests. There seem to be, however, all shades of opinion as to what kind of over-all organization would best meet our needs, and even more divergent views as to how to move from where we now are toward such an ideal.

STEPS TOWARD UNITY

LET US FIRST take stock of the steps that already have been taken in this direction. Some 50 years ago, when Andrew Carnegie made his gift of a headquarters building to the "United" Engineering Societies, United Engineering Trustees (UET) was formed to administer the gift in trust, representing first three, and later all four, of the major engineering societies of that time. UET has continued to administer the original trust and to act for the four Founder Societies in administration of endowments supporting Engineering Foundation and the Engineering Societies Library. American Engineering Council was formed some 30 years ago, as a loose federation of major technical societies, only to be abandoned 20 years later as too poor financially and too weak to be effective. It was succeeded by Engineers Joint Council (EJC), consisting of the four Founder Societies and the American Institute of Chemical Engineers, and EJC is today the nearest approach to an over-all engineering organization, although as a purely consultative federation of member societies, it falls far short of the professional association that at least many of us feel to be necessary.

Another important move of 20 years ago was the formation of Engineers' Council for Professional Development, in which the five constituent societies of EJC joined with Engineering Institute of Canada, American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners, to deal with accrediting of engineering college curricula, the guidance of young persons thinking of entering the engineering field, and encouragement and assistance to young engineers in their technical and cultural studies.

Common action in the field of engineering standards had been achieved by the organization, in the 1920's, of American Engineering Standards Committee, which later became the American Standards Association. This

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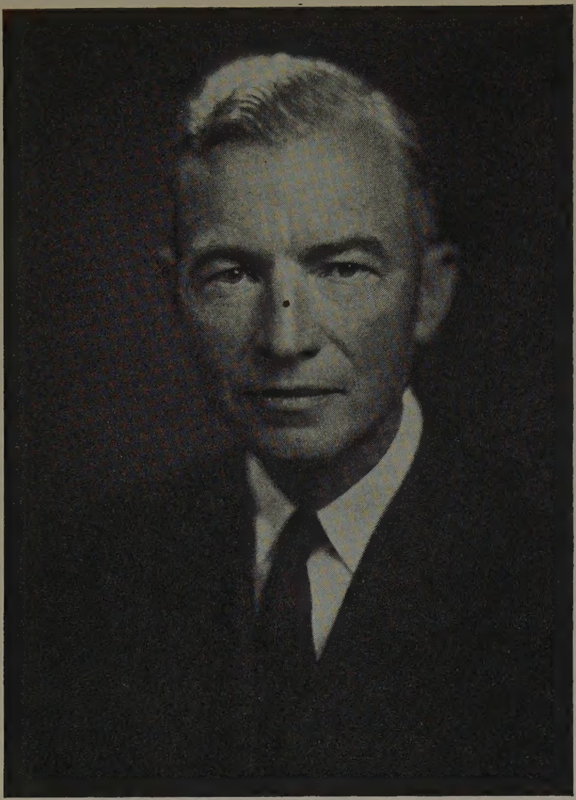
Full text of an address presented at an AIEE luncheon held during the Centennial of Engineering, Chicago, Ill., September 11, 1952.

D. A. Quarles is president, Sandia Corporation, Albuquerque, N. Mex.



D. A. Quarles

organization is supported in its splendid work by all of the major technical societies.

These steps, while significant, leave us a long way short of the goal. AIEE has recognized this for some years, and on its own account has made a number of exploratory moves in the direction of closer organization of the whole profession. These have consisted of various discussions on the Section, District, and national levels. Under the leadership of such past presidents as Wickenden, Hull, Fairman, LeClair, and my immediate predecessor, Professor McMillan, various polls have been taken, all indicating a keen interest in the subject, and all pointing toward a common desire for some effective organization of the profession in which electrical engineering would be one of the technical divisions, but in which individual engineers would have direct membership and a voice in the control of its affairs.

THE EJC PROPOSAL

Three years ago, largely under the stimulus of AIEE interest, EJC set up an exploratory group, consisting of representatives of its five constituent societies, and also of ten other national engineering societies who accepted invitations to participate in the exploratory study. During 1952, the final report of this exploratory group has been filed with EJC, and in line with the recommendations of this report EJC has submitted to its constituent societies proposals to make certain changes in its constitution which would facilitate the broadening of its membership from the present five to include many, if not all, of the other ten national societies which are participating in the exploratory study, on an approximately proportional representation basis.

The AIEE Board of Directors, at its meeting in Phoenix in August, gave broad endorsement to these proposals, thus, as far as the Institute is concerned in this matter, opening the way to a substantial broadening of the EJC base.

This step was not, and was not represented to be, the achievement of professional unity. It was not even a step in that direction, except to the extent that it gives a broader segment of the profession an opportunity to collaborate on matters of common professional interest, and a base of operations from which to move toward a more effective professional association. I believe it is a move in the right direction, and I am hopeful that it is at least a token of more substantial achievement to come.

Perhaps I could do no better in ending this brief discussion of professional engineering organization, than to quote the objectives of such an organization as stated by the exploratory group in its report to Engineers Joint Council.

The objectives are

1. To advance the general welfare of mankind through the technical knowledge and creative ability of the engineering profession.
2. To promote co-operation among the various branches and groups of its engineering profession.
3. To develop sound policies respecting public affairs in which engineering is an important factor.
4. To stimulate engineers to take their proper place, individually and collectively, in public affairs.
5. To enhance the recognition of engineering as a profession.
6. To maintain high professional standards among engineers.
7. To advance the standards of engineering education.
8. To further the professional progress of young engineers.
9. To assist its affiliated societies in the aid and encouragement of the advancement of the theory and practice of engineering.

These seem to me to be sound objectives. Further, I note that they are characterized by the following essential features:

1. They preserve the present technical societies as the primary means of advancing the theory and practice of engineering.
2. In addition to assisting the affiliated societies in this main objective, the professional organization would seek to carry out those aspirations and objectives that are common to the profession as a whole.
3. All of these common objectives meet the criterion of serving the public welfare, as distinguished from the narrower and more selfish interest of serving engineers as a group in their market-place position as against other groups.

There are many hurdles between us and this goal, but I believe that it is a goal worth striving for.

Communications and Electronics

M. J. KELLY
FELLOW AIEE

The president of the Bell Telephone Laboratories reviews the contributions of communications and electronics to America's strength and culture and indicates some significant trends in the evolution of their technology.

When the United States emerged from World War II, it found itself the most powerful nation in the world. That we should eventually arrive at this position was inevitable; it was our historical destiny. Endowed with a great land mass—almost an entire continent—with its richness in natural resources, we have kept it as a single large and unrestricted area for unified development and have become a people politically, economically, and culturally integrated, with a common language, and with a technical efficiency in industry and business unequalled anywhere in the world.

Our rise to this position of pre-eminent power was accelerated by our participation in the two world wars of this century. This participation, with all that it involved, acted as a catalyzer in converting our nation from an agrarian to an industrial economy. Important and essential components of this catalyzation were applied science and technology.

Our conversion from a primarily agricultural to an industrial people in the past 30 years, accompanied by a large growth in number of people and in wealth, has greatly altered the distribution of our population. In 1920 our manufacturing industry was principally east of the Mississippi and north of the Ohio Rivers. Most industries had their manufacture centered in one, or at most two or three, locations. Today, our manufacturing industries are spread across the nation from the Atlantic to the Pacific Ocean and from our southern to our northern borders. Not only have the number of industries multiplied enormously, but the pattern of planning their manufacturing has changed. Dispersion of plants is the order of the day. An ever-increasing number of our industries have manufacturing locations that are numbered in the 10's, 20's, and 30's, and their distribution is nation-wide. Also, small industries act as feeder plants for the large industries. They provide many of the components that are elements of the larger systems produced by the big industries.

A pattern of manufacturing has developed that integrates the many plants of a large industry and its feeder plants of small industry into a single functioning unit. A completed product ready for merchandising flows from this multiplant unit with the continuity and smoothness of the production line of a single plant. This spreads the problems of management, of scheduling raw materials, of product engineering, and of the continuous adjustment of requirements and specifications among units numbering from a few to perhaps 50 scattered throughout the nation. This complex pattern has evolved as an aid in solving the problems of labor supply, and those arising from the ever-increasing technical complexity of manufacture, and in general as an aid to efficient manufacture with minimum cost.

The merchandising of consumer products has evolved similarly into a closely knit national pattern. Banking, trading in commodities and securities, and news distribution are also established on a national pattern of similar complexity.

These examples are typical of the growing trend to make the United States a tightly integrated business community in which on a day-to-day and, in many cases, hour-to-hour basis interchange of information is required between widely dispersed units.

The dynamic communications and electronics industries with their unequalled research and development laboratories have provided the communications networks that have made this industrial and business pattern possible. These networks provide the avenues of instantaneous 1- and 2-way transmission of intelligence, voice, or record, that give to our nation-wide dispersion of business and industry the compactness of "Main Street." Through them, time and distance are conquered. Without them, our nation could not realize the uniquely high level of economic strength made possible by its natural endowments.

The nation-wide interlacings of human relationships that are an essential component of the unified nature of our nation's business and industry promote a similar distribution of social relationships. The extent of acquaintance and friendship of the American family is fast becoming nation-wide. Such relationships are encouraged, and made frequent and intimate, by the qualities of our communication networks. The pattern of telephone traffic, for example, indicates that social calling over the nation-wide telephone system is following the pattern of business.

CONTRIBUTION TO MILITARY STRENGTH

It is a tragedy of our time that in building up our national strength, military power, as well as economic power, must be included. Our need for immediately available military power is a development of only the past 12 years. Although potential military strength bears a direct relationship to economic strength, there never will be any except potential strength unless a large element of

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Full revised text of an address presented as part of the AIEE Participation in the Centennial of Engineering, Chicago, Ill., September 10–12, 1952.

M. J. Kelly is president, Bell Telephone Laboratories, Inc., New York, N. Y.

national effort is dedicated to the development of active military power.

Because the United States pursued the path of peace and military unpreparedness from the close of World War I until a few years prior to World War II, it was not until this latter time that its military organization was dynamically activated and provided with adequate funds for its development. The military, in line with the pattern of industry, at once expanded the scientific and technical work being carried on in its behalf. Before the close of the war a large percentage of the nation's science and technical manpower was devoting its attention to the development of weapons and weapon systems.

This dedication of technologic effort was most rewarding in World War II, and not only hastened and insured victory, but undoubtedly saved the lives of countless Americans. Electronic and communication scientists and technologists were in the forefront in the development of new weapons and the tactics for their use. Almost all of the operations of warfare from reconnaissance to waging battle were revolutionized and made vastly more effective. Radar, sonar, and proximity fuses are typical of the large and significant contribution of our profession. Of all technology, that of electronics and communications made perhaps the largest and most telling contributions to new methods of warfare.

After the close of the war our country provided generous support to the military, which has been greatly increased since Korea. With the background of the revolutionary instruments of war developed in World War II, the military looked forward to even greater mechanization and automatization of warfare. The tempo and character of the warfare they envisioned require speed in evaluation, decision, and action, and precision in operation that are beyond human capacity. Our area of technology by its very nature is providing the directing element, the brain, for such weapons and weapon systems. Evaluation, direction, decision, and automatic operation are being built into the new instrumentalities for war by using the methods and devices of communication and electronics.

The nation's effort in developing weapons is highly productive. We are building great military strength. The contribution of communications and electronics to this strength is as essential as it is to the nation's economic strength. Our economic and military strength are well beyond that of Russia, our potential enemy, although the difference is larger in the economic than in the military field due in part to Russia's greater emphasis on the military. If we continue to devote adequate effort to the military, our economic and military strength should prevent war for many years to come, or in the event that it comes, insure victory, provided our spiritual strength is maintained.

CONTRIBUTION TO CULTURE

THE INVENTIONS of writing and printing are two of the most important contributions to general culture. Although still in its infancy, communications as one of the arts of mass distribution of intelligence bids fair to have an even greater effect. It has been claimed by some that the communication facilities provided for mass distribution of intelligence have led to the vulgarization of culture. It is my view that its contribution to the dissemination of culture among the general public far exceeds the degradation of culture that we must admit occurs in some instances.

Let us make sure we understand what is encompassed by "communication facilities for mass distribution of intelligence." The recording of speech and music and its reproduction by electronic and communication-like reproducing machines was one of the first of these facilities. They have been greatly improved through the years until today almost every home has such reproducing equipment, and the sale of records of the world's finest music, as well as of popular music, is almost astronomical in magnitude.

Communications and electronic technology added sound to the motion picture in the mid-1920's. The addition of sound has enriched the motion picture, enhanced its entertainment value, and improved it as a cultural medium.

Public address systems and radiobroadcasting came into being in the early 1920's. With speech reinforcement, live as well as recorded speech and music may be heard by an audience whose size is limited only by the physical arrangements for its assembly.

Broadcasting by radio transmitting stations scattered throughout the United States and connected by wire networks as is desired makes it possible for all of our citizens simultaneously to hear live or recorded speech and music. Here also the finest music of all time, as well as popular music, is available. Sporting events are described as they occur to audiences limited only by their interest. Entertainers of wide variety become national figures through this medium. Its importance in the dissemination of news cannot be overstated. With the effectiveness of the nation's news-gathering organizations, all of us may hear happenings of general interest as they occur anywhere in the world. A public speaker may have an audience as large as his subject matter will attract. Radiobroadcast, until the recent advent of television, had become the most important vehicle for political contest.

Although television has been in the laboratories of the communications and electronic industry for more than 20 years, it is only within the last few years that it has reached a stage of development for general application. Television broadcasting is following the pattern of radiobroadcasting. It might be said to be radiobroadcasting with the dimension of vision added. Its spread across the country since the close of the war has been a great achievement shared in extensively by the communications and electronic industries. While the present broadcasts are in black and white, color should soon emerge from the laboratory. One can well expect that television broadcasting will be a medium of greater effectiveness than radiobroadcasting. The two probably will be complimentary, and the place of each will be determined by its acceptance by the national audience. Great strides are being made in the laboratory in solving the problems of television programs in theaters. Their solution is assured but the part that television will play in theater entertainment has yet to be determined.

There is an almost universal distribution of some of these facilities in American homes; others are in theaters and public gathering places. The service rendered by them is one of the most significant forces of our time in our cultural development, in the unification of our society, and in preserving our democratic way of life. We are the largest unit of society in the world with a common culture and language. These facilities of our creation are instruments of great power in consolidating and maintaining this unity.

TRENDS IN THE EVOLUTION OF TECHNOLOGY

A GENERAL LOOK at the evolution of our technologies with the perspective of more than 100 years reveals trends of interest and significance.

The basic science that underlies communications was established during the latter part of the 18th and early 19th centuries principally by the men of learning of Western Europe. Harvard University's President Conant has aptly styled them and others of their kind as "uncommitted investigators." These men, who could investigate what they pleased, when they pleased, and break off a research at any point, were free because they had no program except the ever-changing one in their own heads. In our area, Faraday is, without doubt, the giant of the group, but many others, such as Ampere, Henry, Volta, Oersted, Ohm, Gauss, Wheatstone, and Weber, made significant additions to the platform of basic knowledge of electric, magnetic, and electromagnetic phenomena upon which communications technology is built.

With this beginning, the time was ripe for the foundation inventions of communications, and each country justifiably can present its own list of firsts, even though they are in conflict with those of other countries. There was then little publication, and communication was slow. A man in one country could well produce an invention that some 3 or 4 years previously had been made in another country. Morse and Bell are the two names in America that represent the beginnings of telegraphy and telephony. Their pioneer inventions bear the dates 1836 and 1876.

Motivated by Faraday's experiments, Clerk Maxwell, in an attempt to find an acceptable theory of electromagnetism, published his theory of electromagnetic radiation in 1873 in his treatise, "Electricity and Magnetism." This monumental work stands today as the scientific foundation of radio communication. Within 10 or so years, Heinrich Hertz initiated his classical experiments which showed the progressive propagation of electromagnetic action through space. He also measured the length and velocity of electromagnetic waves and showed that in all respects these waves are in complete correspondence with the waves of light and heat. These experiments completely confirmed Maxwell's theory.

The scientific situation was now fully set for the invention of radio communication. It fell to Marconi, an Italian inventor, to make, in the summer of 1895, the radio telegraphic experiments that gave him the first patent ever granted for wireless telegraphy based on the use of electric waves. This completed the basic inventions of telephony and telegraphy by wire or by radiation.

Significant progress was made in all these areas, and commercial use steadily increased. In 1890, for example, there were some 230,000 telephones in the United States, while in 1900 the number had increased to some 1,400,000. However, the broadening of the technology to permit increased and more economical service over greater distances required better oscillators and distortionless amplifiers, which did not then exist. Knowledge from a new area of physics was to supply the basis for inventions that would overcome these deficiencies and create the new technology of electronics that was essential to further advance in communications.

In the last 10 years of the 19th century a new physics was born. It may be said to have begun in 1895 with the discovery of X rays by Roentgen. Many experimenters had already turned their attention to electric discharge through gases. The names of Geissler, Crooks, and J. J. Thomson are high on the list. However, before Roentgen's discovery, work in this field was largely observational. With the background of the X-ray discovery, the physics of conduction through gases was soon unraveled, primarily under the leadership of J. J. Thomson and his school. The determination of the ratio of charge to mass and of the speed of the conducting particles in the gas were the key experiments that provided the basic knowledge. The alpha particle, beta particle, gamma ray, and the electron were identified and studied, and the phenomenon of ionization was explained.

Although experimenters had recognized for more than 200 years that air in the neighborhood of hot solids had the power of conducting electricity, it fell to the J. J. Thomson school, through wisely conceived experiments, to obtain an understanding of the emission of electrons from hot bodies. Owen Richardson, one of Thomson's students, made the more significant contributions. He developed and experimentally proved the law generally known as the "Richardson Equation" that gave the relationship between the electron emissivity of a hot surface, its temperature, and its "work function," an intrinsic property of the surface. Development of thermionic cathodes, the very heart of electronic devices, is anchored to the Richardson Equation.

The new physics established the foundation for the inventions that were to be basic to electronics. Diodes, triodes, tetrodes, and pentodes became the building blocks of the rapidly expanding electronic-communication technology.

In 1905, John A. Fleming, of England, invented the first vacuum thermionic device, a diode, and showed its use for the detection of damped high-frequency waves. This was immediately followed by the invention of the triode by Lee de Forest of the United States in 1907. In essence, the invention inserted a third electrode in the form of a grid between Fleming's cathode and anode. This insertion was of tremendous importance since De Forest's device would operate usefully as an oscillator and amplifier, which is not within the capabilities of the diode. This indeed was an epochal invention, one of the greatest of all times. However, it fell to the lot of industrial research laboratories to perfect and extend its capabilities, and to create a whole new technology of useful applications in communication through completely new types of circuitry.

With the De Forest invention, one era ended and another began. Contributions to our technologies through science and invention up to this point were made by the uncommitted investigator, sometimes called the amateur scientist, and the lone inventor. Team work in the rapidly developing industrial laboratories, and even in the research laboratories of the universities, accompanied by an increasingly effective programmatic approach, are the distinguishing characteristics of the new era. One is inclined to have a nostalgic view of the past era. But time marches on, and with the increasing depth and complexity of scientific and technologic problems, the new era's approach to their solution is essential.

The quantity and tempo of accomplishment of the new era are of a higher order of magnitude than those of the old. With all of its effectiveness, philosophers such as President Conant view it with some concern. They are not yet sure that it gives adequate opportunity for "turning the unexpected corner." Whether or not this is true is left for time to tell.

The first application of the distortionless amplifying properties of the triode in the wire plant extended the distance of transmission of the audio signal. Amplifiers were inserted in the transmitting path as required. Transcontinental telephony soon became a reality. The quality of long-distance service was greatly improved, and large gains in traffic were soon realized.

With a time lag of only a few years, the carrier frequency technique was established, and has been a path of great progress. It is fast narrowing the economic area of audio signal transmission to distances of less than 15 miles.

The bandwidth of the frequencies transmitted has been steadily widened. For years the transmission path was a pair of wires, either pole mounted or in intimate association with hundreds of other pairs in a lead-covered cable. Fifteen years ago a coaxial structure became available as a conducting path.

The transmitted bandwidth grew from the 4,000 cycles of the voice frequencies to a few hundred kilocycles in the 2-wire structure, then first to 3 megacycles, and now to 8 megacycles in the coaxial structure. The 8-megacycle bandwidth permits the simultaneous transmission of almost 2,000 telephone messages by two coaxial structures, one for each direction.

The broadening of the transmitted bandwidth has made major reductions in cost per circuit mile, and large savings in material, particularly copper and lead, and thus has become a matter of great importance to national strength.

In radio's utilization of electromagnetic radiation for communication, a low-frequency carrier of a few hundred kilocycles was early employed. With the progress of our technology, carrier frequencies have steadily moved upward. Megacycle carriers were soon realized, carriers in the hundreds of megacycles followed, and in recent years our top carrier frequencies are measured in the thousands of megacycles. The top frequency for commercial service is now in the 6,000-megacycle range. As the carrier frequency has increased, the bandwidth of transmission also has been widened until today 4-megacycle bandwidths are in use and technology is available for materially widening this band.

The attainment of megacycle bandwidths was fortunate for the development of television on a national basis. Our national television network employs coaxial and repeatered radio, each with a bandwidth of some 4 megacycles. Technology is now available for its widening as required.

These developments in transmission have been paced by the advent of new electronic devices. The pentode was essential to the exploitation of broad-band transmission. An exterior anode tube, water, and later air, cooled, was essential to transoceanic telephony and to broadcast transmitters of more than 5 kw output. Progress toward higher frequencies became slow when 500 megacycles was reached. The invention of new electronic devices was essential. High-power applications, radar, for example, at this and higher frequencies awaited the invention of the multicavity pulsed magnetron. With its availability, the frequency range of radar application moved rapidly upward, and at the close of World War II had reached 30,000 megacycles.

The invention of the klystron provided the first amplifier in the 1,000 or higher megacycle range. It had limitations, however, that placed restrictions on the bandwidth it could amplify and the number of amplifications permitted in a repeatered system.

The invention of the traveling-wave tube in the late years of the war gave promise of the ideal amplified for carrier frequencies as high as 30,000 megacycles and transmission bands of more than 100 megacycles in width.

The Bell System's recent need for megacycle bandwidth amplification with a 4,000-megacycle carrier for its nationwide repeatered radio network did not permit waiting for the development and standardization of traveling-wave tubes. Bell Laboratories, therefore, extended the art of the coplanar grid triode by developing techniques of "watchmaker plus" precision. This permitted the standardization of a triode operating at 4,000 megacycles with a 4-megacycle bandwidth. This is probably an interim solution. The traveling-wave tube now appears to be the answer to broad-band amplification in the 1,000-megacycle and higher frequency range.

Although electron and high-vacuum physics have been at the heart of communication progress, the contributions of solid state physics have slowly increased in scope and importance. Improvements in dielectric and magnetic materials over the years have been of great significance. Piezoelectricity is making a continuing contribution to the frequency control of oscillators and to transmission networks. Semiconductors made their entry with the copper-oxide varistor, which has been of value as a modulator and demodulator and as a rectifier in the power supplies for communications systems. The selenium diode for similar uses soon followed. The thermistor has been important in stabilizing the gain of long-distance circuits against temperature variations as well as in other applications.

Silicon diodes were widely used in the receivers of the radar systems of the war. Wartime researches also made available the germanium diode. In the postwar years the germanium diode has found very wide use, more extensive than that of the silicon diode.

A basic research program on semiconductors initiated at the Bell Laboratories under the leadership of William Shockley after the close of the war led to the invention of a semiconductor triode employing germanium—the transistor. This invention well may rank in importance with the audion. Because of the extremely low level of energy and voltage required in its operation, the transistor promises not only to replace the triode in many of its applications, but also to make large and significant contributions in other areas of communication technology. For example, it will play a large role in the local telephone plant where for economic reasons the vacuum tube has played a relatively small part. It appears ideal as a circuit element in the new field of electronic computers. Because of its ruggedness and low power consumption, it will be of increasing importance in many military electronic applications. It will also increase the application of electronics to the noncommunication industries. Solid state physics in the years to come may even replace high-vacuum and electron physics as our most significant supporting area of basic science of communications and electronics.

Up to the time of World War II, electronics was principally the servant of communications. A major part of its research and development was carried on by the communications industry. With the gradual rise in industrial applications of electronics to both power and control uses, there has been electronics development by these industries. The entry of electronics into military weapons systems led, during World War II and the succeeding years, to an increasing volume of electronic research and development for military applications. The communications industry along with the laboratories of the military up to now have been responsible for a major portion of the military electronics developments of the country. However, because of the importance of electronics to the weapon systems of the airplane and to guided missiles, many of the airplane manufacturers have established electronic research and development laboratories in the postwar years. Industries primarily interested in the ordnance of the Army and Navy are also entering electronic development.

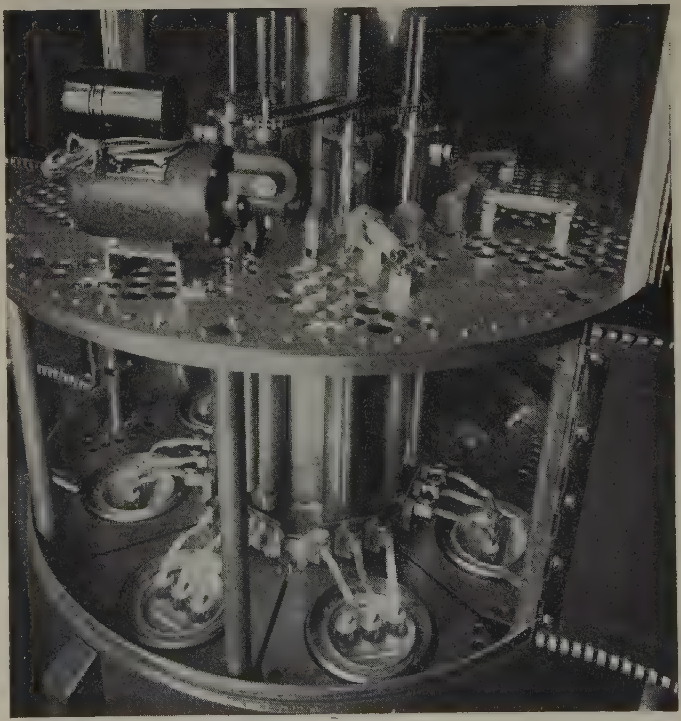
With the recognition of the part the transistor is destined to play in computers, and in control and programming functions for industry and business, new laboratories are being established to exploit these fields. They will, of course, not neglect vacuum-tube electronics. The communication industry, therefore, will share increasingly with others the exploitation of electronic devices for national use. In the interest of the nation this is a constructive trend. It will add to our national strength in both the economic and military areas.

THE LOOK AHEAD

There never has been a time when the communications field could map out so large an area of opportunity as now. Even with the tremendous growth of the last decade in the use of communications, the trends of the nation's industrial and social development, and the steadily rising national income give assurance of almost unlimited growth in the demands for communications service.

At the research stage, work is in progress in communications and electronics laboratories that insures a large reservoir of new knowledge that will lead to enhanced technical progress. General communication and electronic research point to a continuing flow of new knowledge that should improve existing communications services and provide completely new facilities for meeting the large demands of the future. It is not an overstatement to say that there can be no communication need that our technology will not supply. Solid state physics and device research present vistas of new facilities for communications, the military, and for wide new areas of industry and business. The instrumentation of weapon systems that is uniquely in the province of communication and electronics technology is in its beginnings. Revolutionary progress in function and in reliability is ahead. All of this is good for the nation, for as our technology grows, and as the area of its application expands, an increase in our nation's strength and a rise in general cultural level of its people will surely follow.

Equipment for Stronger TV Signals



A new very-high-frequency conversion amplifier, designed by the Radio Corporation of America to step up the power output of any current 5-kw transmitter to either 25 or 20 kw, depending on channel, will make possible television station power boosts for many communities. The new equipment consists of aural and visual power amplifier and blower units, supply and filter units, control units, vestigial side-band filter, and other accessories

E. O. Lawrence—Faraday Medalist

SIR JOHN HACKING
ASSOCIATE MEMBER AIEE
PRESIDENT, INSTITUTION OF ELECTRICAL ENGINEERS

The 1952 Faraday Medal of the Institution of Electrical Engineers of Great Britain has been awarded to E. O. Lawrence, director of the Radiation Laboratory at the University of California. Presentation was made during the recent Centennial of Engineering celebration in Chicago.

It IS A GREAT privilege for me as the reigning president of the Institution of Electrical Engineers to be present in Chicago to attend the Centennial of Engineering, which celebrates the 100th anniversary of the founding of the American Society of Civil Engineers, and it is a still more intimate privilege to be present at this function of the AIEE whose aims and objectives are so close to our own and with whom my own Institution has had so many years of active collaboration. Apart even from that, I am also participating in a family reunion since I personally have been on AIEE membership rolls for well over 30 years.

For all these reasons, Mr. President, I am very happy indeed to bring to you the heartiest and most friendly greetings of the Institution of Electrical Engineers.

I feel particularly honored at being entrusted with the responsibility and pleasure of expressing the appreciation, not only of the three British Institutions, but also of all of the foreign institutes and associations attending the convention. I am sure I am expressing the views of all these bodies in conveying to you, Mr. President, and to your Institute our grateful thanks for the great kindness and hospitality we have received at your hands. The work done by the AIEE is the object of our great admiration, not only for the wonderful technical work you achieve, but also for the way you are carrying out your responsibilities to the profession of electrical engineering. Bodies such as those we all represent have the duty of ensuring the maintenance and even the improvement of the high standard of technological competence and of behavior of members of the profession in our different countries. As has been emphasized many times during the proceedings of the Centennial, work to be done by engineers in furthering the advancement of world economy is ever growing and we must do all we can to ensure that this work is carried out both technically and in other ways so that the reputation of the word "engineer" is maintained at the highest possible standard.

Professor Lawrence (left) accepts Faraday Medal and scroll from Sir John Hacking

My Institution and myself as its president are also very grateful to you for allowing me to make this the occasion of the presentation to Professor Lawrence of the Faraday Medal for 1952 and perhaps you will allow me first to say something about this medal and the significance of it to the Institution.

ESTABLISHMENT OF MEDAL

In 1921, we celebrated the 50th anniversary of the founding of the Society of Telegraph Engineers, whose name was changed to that we now bear in 1888. At that time we decided to inaugurate an annual award and it was necessary to decide on the name and the nature of that award. It was natural that the thoughts of the council should turn to Michael Faraday, that brilliant but modest investigator who first discovered the principle of electromagnetic induction which is the foundation stone of all modern electrical engineering. The whole of the great electric power industry stems from the principles first established by Michael Faraday as the result of prolonged careful and methodical experimental investigations carried out at his laboratory in the Royal Institution of London. Michael Faraday was a modest and retiring man who in his lifetime rejected many honors which were offered to him and it was appropriate that this should be borne in mind in deciding the nature of the award which was under consideration. It was decided, therefore, that the award should consist of a bronze medal on which Faraday's head is depicted. It is perhaps worth recording

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Full text of an address made in conjunction with the presentation of the Faraday Medal at ceremonies held during an AIEE-sponsored luncheon at the Centennial of Engineering, Chicago, Ill., September 11, 1952.

Sir John Hacking is Deputy Chairman, British Electricity Authority, London, England.

that the highest and most cherished medal available to members of the fighting forces of the British Commonwealth is a small bronze medal known as the Victoria Cross.

The determination of fundamental principles, valuable though it is, does not in itself result in value to the human race. The application of these principles needs to be developed and carried out by a great number of research and industrial workers and this work is carried out in many different countries.

The award of the Faraday Medal, which is made not more frequently than once a year, is therefore for notable scientific or industrial achievements in electrical engineering or for conspicuous service rendered to the advancement of electrical science without restriction as regards nationality, country of residence, or membership of the Institution. These requirements cover not only the type of fundamental research for which Faraday is famous, but also distinguished service in the development of the science which stems from that type of research work. The first award was made to Oliver Heaviside and the names of subsequent recipients include many of the world's leading scientists; to name only a few, Sir J. J. Thomson, Dr. Frank B. Jewett, Sir Ambrose Fleming, Dr. Irving Langmuir, Lord Rutherford, and Professor Andre Blondel.

ACHIEVEMENTS OF THE MEDALIST

The Council of the Institution decided to make the award to Professor Lawrence because of his very distinguished work in the field of nuclear physics. He is director of the Radiation Laboratory of the University of California, where he became professor of physics in 1928.

Professor Lawrence's early researches were concerned with photoelectric effects and in 1930 he became interested in the possibilities of using the method of resonance acceleration in order to obtain positive ions of very high energies by means of a number of consecutive accelerations through relatively low differences of potential. His recognition, however, of the limitations of this method of linear resonance acceleration led him to conceive and build the first cyclotron which he used to study the transmutation of elements and artificial radioactivity. For this work he was awarded the Nobel Prize for physics in 1939.

During the last war Professor Lawrence was a member of the team of American and British scientists concerned with the development of fissile materials. The need for larger samples of uranium 235 than could be obtained by the mass spectrograph method led him to investigate the large-scale separation of uranium isotopes by electromagnetic methods. He achieved success by employing the "Calutron" mass separator and this method of effecting the large-scale separation of uranium isotopes was adopted in preference to the two other methods (the centrifuge and diffusion systems) which were under investigation at the same time.

Professor Lawrence has been the recipient of many honorary degrees and other honors, including the Hughes Medal of the Royal Society and the Duddell Medal of the Physical Society of London. I hope he will regard the new award as really to rank with those he already possesses. I cannot help thinking that Michael Faraday would himself be glad to know that an award with his name was being made to one who like himself is so distinguished in the field of experimental research even though this is in a branch of which Faraday himself could hardly have had any conception.

The work for which Faraday and Professor Lawrence are famous is in the realm of physics rather than engineering. It is quite appropriate that the award should be made in this field since our Institution, like your own, owed its initiation to a group of men who could be regarded as physicists rather than engineers. Indeed the differentiation between the two is sometimes by no means clear.

PRESENTATION OF THE MEDAL

It gives me very great pleasure to present to Professor Lawrence the Faraday Medal, together with the scroll which has been signed at Westminster under the seal of the Institution. I would incidentally draw your attention to the fact that the Institution's seal also includes the bust of Faraday, which is another indication of the honored place which he holds in the affections of my Institution.

Sir John Hacking delivers the Faraday Medal presentation address

Response of the Medalist

Deep appreciation was expressed by Professor Lawrence for the receipt of this distinguished honor and he said that it was uppermost in his mind that the award was made by engineers. He pointed out that the success of the Radiation Laboratory was largely due to the work of engineers. During the war, a group of British engineers worked with the Americans on the Manhattan Project and a very warm friendship developed. In conclusion, Professor Lawrence expressed the hope that Sir John would convey his very deep appreciation to the Institution of Electrical Engineers.

Determination of Unbalance of Untransposed Lines

R. F. LAWRENCE
MEMBER AIEE

D. J. POVEJSIL
ASSOCIATE MEMBER AIEE

DURING THE EARLY YEARS of the electrical industry it was found that transmission-line transpositions were essential in order to reduce undesirable communication circuit interference. This was due largely to the extreme susceptibility of early communication circuits to both 60-cycle and harmonic frequency disturbance. However, developments in communication practice have reduced greatly this justification for power-line transposition, such as the use of underground or otherwise shielded circuits and separate rights of way.

Coincident with the advancements in communication technology has been the growing realization among power systems engineers that transpositions are not only extensive but that the transposition structures are weak links in the system both electrically and mechanically. Some studies have shown that 25 per cent of all outages are associated directly with a transposition. Therefore, the practice of transposition has been abandoned by some large utilities.

For any conductor configuration, a certain amount of dissymmetry always will exist. Even for equilateral spacing the conductor arrangement is unbalanced with respect to ground. Such dissymmetry has the effect of causing voltage and current unbalance in the power system. In order to eliminate this unbalance, the line can be transposed completely between each switching station. By this method, each phase conductor will occupy each of three possible positions for a third of the distance between switching stations. Thus, the geometric unbalance of the conductor configuration is averaged out. In the teminals the phase impedances are equal.

In order to calculate the unbalance which results when the line is not transposed, the problem is separated into two parts: the currents and voltages resulting from electromagnetic unbalance; and the currents and voltages due to electrostatic unbalance. This division is necessitated by the extreme complexity of the problem when both types of unbalance are considered simultaneously.

The basic methods of treating unbalanced inductive and capacitive reactances are reviewed in this article. It is found by making certain assumptions that the negative- and zero-sequence currents due to inductive unbalance can be expressed as: $I_2=K_{21}I_1$; and $I_0=K_{01}I_1$; where I_1=load current; K_{21}=inductive coupling factor between negative- and positive-sequence networks; and K_{01}= inductive coupling factor between zero- and positive-sequence networks.

In like manner, the negative- and zero-sequence currents due to capacitive unbalance can be expressed as: $I_2=K_{21}'I_1'$; and $I_0=K_{01}'I_1'$; where I_0'=normal charging current of line; K_{21}'=capacitive coupling factor between negative- and positive-sequence networks; and K_{01}'= capacitive coupling factor between zero- and positive-sequence networks. The coupling factors, K_{21}, K_{01}, K_{21}', and K_{01}' are functions of line configuration and can be calculated.

CONCLUSIONS

1. The method which is given here is useful for determining the negative- and zero-sequence currents caused by inductive and capacitive unbalance in an untransposed line.

2. Representative average values of negative- and zero-sequence current due to inductive unbalance are 6.4 per cent and 1.0 per cent, respectively, of the positive-sequence load current. Line configuration and terminal impedances affect these values.

3. Negative- and zero-sequence currents due to capacitive unbalance are not affected by load currents and terminal impedances, but essentially by the line configuration and the line length. Representative average values of negative- and zero-sequence currents are 5.5 per cent and 1.8 per cent, respectively, of the normal balanced line charging current.

4. The negative-sequence current produced by an untransposed line may be high enough to unbalance the current in rotating machinery and cause additional heating.

5. Zero-sequence current caused by an untransposed line may cause tripping of very sensitive ground relays at the terminal equipment.

6. Interference to communication circuits is limited to open-wire telegraph circuits and is a result of a 60-cycle induced voltage resulting from a flow of zero-sequence current. Communication circuits usually are well shielded and in many cases do not parallel transmission lines; this reason usually will not justify transposition of a line.

7. For unbalanced or balanced short-circuit calculations, the effects of unbalanced impedances due to an untransposed line need not be taken into account.

8. The transposition of transmission lines represents higher cost of a line due to the transposition towers required. In addition, the transposition of a line results in lower mechanical and electrical strength. These factors make it desirable not to transpose lines if the effect of an untransposed line are not adverse. Several utilities are building untransposed lines with no apparent trouble.

9. It was not intended to evaluate the necessity for transposing of lines, but to show how the unbalanced currents which result can be calculated. The factors which must be considered are mentioned so that the system design engineer can evaluate his own case.

Digest of paper **52-148**, "Determination of Unbalance of Untransposed Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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The Electrical Engineering Profession in the Past Century

M. D. HOOVEN
FELLOW AIEE

During the past 100 years, electricity has evolved from a parlor trick to the tremendous and vital role that it plays in American life today. Paralleling the advances in engineering has been the rise of the engineering societies, with the first of these, the American Society of Civil Engineers, being founded in 1852. The AIEE was organized 32 years later.

THERE WERE FEW electricians a century ago. There were few even though this rather descriptive term as then used included everyone, from artisan to professor, who thought about or dealt with electricity. A science textbook of that day devotes, out of 400 pages, only 20 to electricity, with most of these discussing lightning. "It is dangerous to be in a crowd during a thunderstorm because a mass of people forms a better conductor than an individual and because the vapor arising from a crowd increases its conducting power." "There are two kinds of Electricity—one Vitreous, the other Resinous: more frequently called Positive and Negative Electricity." Electricity, galvanism, and magnetism were said to be much the same; "but philosophers are as yet ignorant of its nature." A hydroelectric machine developed electricity "in enormous quantities" by the rapid escape of steam through a small orifice. An electric machine in general was a generator of frictional electricity. Such machines were popular at parties. "The lady takes hold of a chain connected with the prime conductor. The machine being then put in motion, the gentleman approaches the lady, and immediately he attempts to imprint the seal of soft affection upon her coral lips, a spark will fly in his face, which generally deters him from his rash and wicked intention."

Electricity was soon to become serious business on the railroads, however. The telegraph, 8 years old a century ago, was to expand with the railroads. Before too many years would pass, every good-sized town in the nation would be reached by railroad and telegraph. Much of the engineering energies of the day were poured into these major activities.

Nor were the mechanics idle in that period. Developing along with the railroad trackage was the locomotive and, preceding it, the stationary engine. Coal was coming into use to replace the water wheels supplying mechanical power for the factories that were rapidly springing up over the northern area. The gold rush was on; mining problems occupied many of the civil engineers of the period.

The War Between the States disrupted technological advancement, but only briefly. Nearly every year between the close of the civil conflict and the end of the century witnessed some signal achievement in the realm of applied science. Cable communications with England were opened in 1866, railway block signals the next year, Edison's quadruplex telegraph was introduced a few years later. The postwar drive to tie the continent with steel witnessed the first joining of transcontinental rails in 1869, the telegraph transcontinental tie having anticipated the railroad by 8 years. The last spikes were electrically connected by telegraph wires with leading cities in all sections of the country. The final strokes of the sledge hammers on the golden spike instantaneously informed the nation that the old geographic frontier had been closed and by implication informed any who would stop to think that the first forays were being made along the new frontier of engineering.

Through the 1870's, new engineering advances paved the road for the greater ones which were to follow. The development of the electric light, the electric dynamo, and the telephone, forerunners of a new civilization, was halted only momentarily by the panic of 1873. The exhibition at the Centennial celebration of 1876 in Philadelphia provided a great impetus for the products of applied science.

COHESION AND DISPERSION

OPPOSING FORCES of cohesion and dispersion were beginning to show themselves within the American Society of Civil Engineers (ASCE). Although the establishment of local sections within the parent engineering body had been suggested as early as 1873 it was rejected by the "older, distinguished" members, many of whom also felt that the civil engineers traditionally were the engineers who planned a general project, such as a railroad or canal, leaving with the mechanics for development a general specification for the particular machine or accessory required. It was also pointed out that the members of the society seldom, if ever, held operating positions in the new enterprises.

The cohesive viewpoint was perhaps best presented by ASCE President Chanute in his 1880 address, "Engineering Progress in the United States." He discussed, among other things, the work of members of the ASCE in the field of telegraphic engineering and had high praise for the mechanical engineers. Apologizing for going "far afield," he

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Full text of a paper, "Evolution of the American Institute of Electrical Engineers," contributed to the Symposium on the Role of the Organized Profession held at the Centennial of Engineering, Chicago, Ill., September 3, 1952.

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said he followed the practice of classifying marine, mechanical, telegraphic, gas, and mining engineers as civil engineers, thus using the term civil engineering solely as a differentiation between civilian and military engineering. He deplored the continued organization of local clubs and specialized engineering societies. In conclusion, he flatly stated that there was room for but one first-rate civil society, which would include all branches of engineering. He viewed the effect of dispersion as contrary to the good of all.

For the moment, however, the forces of dispersion were in ascendancy. The American Institute of Mining and Metallurgical Engineers (AIME), of a background that was "civil" even in the restricted use of the word, had been established in 1871; the mechanics established The American Society of Mechanical Engineers (ASME) in 1880; the electricians were soon to establish their own Institute.

FOUNDATION OF THE AIEE

The founding of AIEE came about rather simply. The art having benefited so greatly from the applied science display at the Centennial Exposition of 1876, the Franklin Institute issued invitations for another international electrical exhibition in Philadelphia, Pa., in the fall of 1884, which opened with a National Conference of Electricians. The Congress of the United States had issued special invitations to a number of foreign electricians and scientists to attend, but there was no specific American organization to receive them. A call went out for the formation of such an organization, signed by 25 men describing themselves as electricians, engineers, and scientists. Thomas Edison, one of the signers, represented himself as an inventor, rather than as an engineer or telegrapher, although he and 20 others of the 25 were associated with telegraphy. There was no difficulty in starting the new organization; a number of engineers apparently were ready and eager to join. The New York Electrical Society, by that time 3 years old, supplied many of the Institute's first members. The Constitution and Bylaws seem to have been patterned after those of the AIME and, once organized, the new Institute's headquarters were located in the building of its parent society, the ASCE. The first paper, read at the first convention in Philadelphia in the fall of 1884, considered the "Edison Effect," the transmission of electric current through space within an evacuated tube. Discussion brought forth no specific explanation and the invention of the vacuum tube as it is now known was delayed for another score of years.

The mechanical engineers as well as the electrical engineers had their early headquarters in "their father's house," the ASCE building. Many of the members of each society still maintained their membership in the parent body, and apparently not all members of the parent ASCE were happy with the split-up in the profession. In 1885 a resolution to appoint a committee to investigate possibilities of absorbing local engineering societies and of including other branches of the profession in ASCE was discussed. It was stated unofficially that the mechanical and electrical engineers had asked for recognition and when it was denied had formed their own societies. However dispersion, unleashed, already had gone too far. Unity of organization had been lost for a period that would extend well over half a century and dispersion remained to plague the profession, not only through splinters of the first block, but through splinters of splinters of splinters.

Although unity of organization had been lost, the profession did not drop even momentarily its potential for unity of purpose and unity of action. The first joint effort by the four societies (ASCE, AIME, ASME, and AIEE) was in 1885 when they sought to have a National Committee for Testing Materials established by the Congress. The same year, however, saw a continuation of the tendency to splinter when The National Electric Light Association (NELA) held its organization meeting at Cleveland, Ohio. Included were all types of electrical engineers, from the operators to the professors. Destined to become one of the great engineering forums on the supply and utilization of electric energy, its coverage of company and individual members became nation-wide in the 1920's when it had developed state and regional divisions, with a total participation of literally thousands of engineers. Nor was the communication aspect of the electrical art neglected in the new body; the major portion of its first meeting was devoted to the problem which 35 years later was dubbed "inductive co-ordination," the art of engineering power and communication electric systems in such fashion that they could exist together. In the 1920's, large contributions of men and money were made to fundamental electrical engineering research in this field by NELA and the Bell System. Advancements in the electrical art are continuing to be made by NELA'S successor, the Edison Electric Institute, now organized as a trade association with capable engineering committees. The Association of Edison Illuminating Companies, organized in the same year as NELA, contributes similarly, as do the manufacturers' associations. The technical trade associations, which are set up on a company membership rather than on an individual membership basis as are the professional societies, made great contributions to the progress of electrical engineering through their technical committees. In general, the engineering committee members of these bodies are members of AIEE, although a considerable number of ASME and ASCE members are also included.

Expansion in the electric traction field, the rapid growth of use of the trolley car, caused a similar development of the American Electric Railway Association (AERA) in 1903. Engineering sections of the Association of American Railroads and AERA, both signal (communication) and power, showed large participation by electrical engineers. AIEE records of the period are replete with presentations and discussions of motor and generator design, new signal systems, and the like.

By 1900, AIEE had 1,000 members. Its administration was organized on an ultrademocratic basis, its president, six vice-presidents, and 12 managers being nominated by individual choices indicated on a list of the entire membership. A few years before the turn of the century, electrical engineering courses were established in most of the 110 colleges where engineering was taught. The first two began in 1883. The rapidity with which the colleges instituted such courses had its influence on the nation's unparalleled advances in the technological field.

The electricals, however, like their sister bodies, still confined their national organization to the eastern seaboard, although thoughtful Institute members were considering the problem of geography. The attempt to hold parallel New York and Chicago meetings met with some success. Local sections were beginning to form. Too little attention was paid to the expanding field into which the art was being carried. A committee of older members commissioned to survey cleavages felt that the Electro-Chemical Society (1902) might have been organized within the Institute had its policies been broader. In 1905 a group of electrical engineers met to form a society to represent the science and art of illumination. Although gas engineers were included, almost all the organizers were AIEE members. The inaugural address of the first president charged that the electrical engineers had not applied their skill after energy reached the socket; they were too busy with generation and transmission. The Illuminating Engineering Society is now 47 years old with a firm record of substantial accomplishment in the field of electrical illumination; a large portion of its members are also members of AIEE. In 1907 the Association of Iron and Steel Electrical Engineers (since 1936 the word "Electrical" has been omitted) was founded to increase co-operation between the makers and users of electric apparatus for the iron and steel industry, apparently a job not too well done by AIEE.

THE IRE IS FORMED

Communication and power supply obviously were the major interests of AIEE for many years. There was an early coverage of wireless, a Marconi exhibit and a wireless discussion having been held before 1900. Among important communication papers were De Forest's "Audion" and Fessenden's "Wireless Telephony." Perpetuating the errors of its forebears, however, AIEE seemed to find too little room for papers and discussions from the engineers who were operators in the new art. The Society of Wireless Telegraph Engineers and the Wireless Institute, both of which had been in a precarious organizational position, combined in 1912 to form the Institute of Radio Engineers (IRE). Again the majority of original members were members of AIEE, a condition which seems to have prevailed for many years after its founding. How large a number of today's 50,000 AIEE members and enrolled students and IRE's 30,000 belong to both societies awaits someone with sufficient patience to check the lists. Undoubtedly there is a large number of duplicate memberships. Again, however, lack of unity of organization has failed to prevent unity of purpose and action. Scores of joint technical operations are carried on. For engineering students in colleges, a modus vivendi of Student Branch operation has been worked out so that one group of electrical engineering students can establish official ties to both societies. If criticism is directed against the main body of electricals for not recognizing the great technical potentialities of radio, it must be remembered that the engineers of the early 1900's were engaged in laying the foundation of the tremendous growth of the power and telephone systems which occurred in the "roaring '20's." World War I was having its inflationary effects. AIEE was plagued with the familiar problem of too many papers and too little money to publish them all. The infant radio science interested at most only a few hundred engineers. It is not surprising that too little aid was given to the new branch of the art.

During the period of dispersion among the electricals, however, larger forces of unity and cohesiveness were at work. The Latimer Clark library, then the second most important electrical and scientific library in the world, was presented to AIEE by Dr. S. S. Wheeler, later to become president of the Institute. To stimulate the movement for a home for the Institute, which then occupied fine quarters as guests of The American Society of Mechanical Engineers, Dr. Wheeler attached a condition that a suitable building be provided for his library. Andrew Carnegie indicated a willingness to consider financial support. When AIEE representatives called on him, Carnegie asked for a plan which was developed into a "union building." On February 14, 1903, he wrote a check for a million-dollar valentine to start the building which was to become the national center of engineering. The following winter the American Society of Civil Engineers voted not to join in accepting the gift. Instead of the project being jettisoned, however, a new impetus was given to it by the necessity of recruiting smaller engineering and scientific societies. In 1904 Carnegie wrote a new letter addressed to the three societies and The Engineers' Club, which had been organized in 1888, increasing the gift to $1,500,000. The Engineering Societies Building on West 39th Street, and its neighbor, The Engineers' Club, on 40th Street, were dedicated in 1907. Carnegie remarked that "the telegraph boys will now have a comfortable place to meet." Carnegie, himself, was an ex-telegrapher.

Ten years later, when ASCE decided to join the Founder Societies, the Engineering Societies Building took on a significance greater than simply that of society headquarters and library. It provided a center for all engineering activities. Even while the civil engineers temporarily refrained from completing the unity of headquarters location, they continued to demonstrate unity of purpose and unity of action as various circumstances required. The Engineering Foundation and the United Engineering Trustees soon provided a place for continued co-operation of the Founder Societies.

It must not be supposed that, during the period of dispersion within itself, the AIEE administration took the various defections from the parent body too complacently. In 1916 the Board of Directors established a Board's Committee on Technical Activities to meet the criticisms that were being lodged against the technical committees for not completely covering the field of electrical engineering. The Meetings and Papers Committee suggested that Section chairmen in addition to technical committee chairmen become members of the committee so that the technical work could be spread farther afield.

THE SECTIONS OF THE INSTITUTE

The Sections at this time were showing indications of the importance of the part they were to play later on in the life of the organization. While most of the Institute meetings were traditionally held in New York (monthly meetings were held there until 1918), early attempts were made to spread the technical work geographically. Upon petition of 20 members, meetings might be held in any city at the same time as those held in New York, the same papers being read and discussed simultaneously at all meetings. The Chicago group took the greatest advantage of this procedure, with meetings as early as 1893. After 1902, independent local meetings and activities became more prominent. The first Section organized under the present system was the Minnesota Section, whose 50th anniversary was celebrated concurrently with the Summer General Meeting in Minneapolis in June 1952. Pittsburgh (Pa.), Ithaca (N. Y.), and Urbana (Ill.) followed in the same year. Groups of engineering students in universities and technical schools were organized as Branches. The members of both Sections and Branches multiplied quickly and with this came a more rapid growth in Institute membership. More than 30 Sections had been established before 1920.

Probably as a result of the soul searching occasioned by the organization of satellite engineering societies, the number of technical committees had grown to 15 during that same period. The first of the modern technical committees, the Transmission Committee, was established in 1902. The technical committee structure seems to have developed without too much preliminary planning, but as the result of the pressure of papers and discussions which came about through the expansion of Institute membership.

Also as the result of Institute self-analysis in the early 1900's, the organizational structure was changed by the pressure of the new geographic pattern of electrical engineering coverage. Ten geographic Districts were formed, with each District headed by a vice-president who had developed a kind of parochial responsibility toward the Sections in his District. The new Board of Directors reported that because of its changed complexion, its meetings were held in various cities throughout the country. New York was no longer the focal point of electrical engineering. Members in the New York area became a part of the New York Section, last of the great city Sections to be organized, although this Section did not reach an autonomy comparable with the other Sections until as late as 1945. In the case of Section activity, geographical dispersion of administration worked toward administrative cohesion of the Institute as a whole.

The tremendous expansion of electrical engineering in the 1920's brought about further organizational strains within the Institute. In 1925 a report on the development of the activities of the AIEE technical committees proposed a scheme of organization which could receive, co-ordinate, and apply the work of the technical committees. The development of standards was becoming of extreme importance. AIEE, traditionally interested in standards, took the lead in evolving the American Engineering Standards Committee, which later became the American Standards Association.

The work on organization of the technical committees continued under the sponsorship of some of the most active personalities in the Institute for a 10-year period. Finally in 1933, under the chairmanship of R. N. Conwell, the Technical Program Committee proposed a delineation of scopes of technical committees and an outline of administration that became the basis of technical operation for the next decade.

PROBLEMS OF CO-OPERATION AND GROWTH

During the same general period, AIEE continued to support cohesive efforts within the profession. In 1920 American Engineering Council, now defunct, was organized by the national mining, mechanical, and electrical engineering societies (the civil engineers not participating until about 10 years later) and other national and local societies. In engineering education also, AIEE members were co-operating as usual within the Society for the Promotion of Engineering Education (now American Society for Engineering Education). At least indirectly as a result of W. E. Wickenden's SPEE work on investigation of engineering curricula, both in Europe and the United States, and his repeated exposition of the responsibilities of the professional societies in the educational field, the Engineers' Council for Professional Development (ECPD) was established in the early 1930's. AIEE has continually and consistently supported the excellent inter- and intrasociety work of ECPD.

The depression of the 1930's saw a slackening of AIEE activity. The Institute lost 25 per cent of its members temporarily. While the development of the art did not stop, the number of papers contributory to it was materially lessened, a phenomenon which reoccurred with the impact of World War II. The end of the war, however, brought with it a great influx of technical material which had been temporarily dammed up by governmental restrictions on the publication of classified material. Foreseeing the huge growth in technical activity that would follow the termination of the war, the Board of Directors issued its Asheville Resolution in 1946. The Asheville Resolution in effect recommended formation of additional technical committees as needed to cover the important items of electrical technology; grouping of these technical committees in appropriate divisions; and provision for the administration and membership participation in the complex interrelation of the various sectors of the electrical field.

AIEE membership has more than doubled since 1940; the total number of technical papers likewise. Similarly, increased activity has taken place within the Sections. The division of the technical work of the Institute into functional groups has tended to promote cohesion within the national body rather than disunity. The work of the Sections often is divided into fields of activity which parallel those of the general organization. More often than not, however, different divisions of work in the Sections have been adopted, depending on the community which the Section serves. Within the sister society, IRE, the same trends are appearing. IRE's administration is fostering the formation of professional groups with the stern admonition that any grouping of specialized segments should be a closely knit union with centralized management that can capitalize on existing strength rather than a loose federation of semiautonomous societies. IRE's membership has experienced a fivefold increase since 1940, and cohesion versus dispersion must be thought about even more thoroughly than in AIEE. AIEE is embarking on a new publication program which will make immediately available technical papers in the following groups as bimonthly publications: Electronics and Communication, Applications and Industry, and Power Apparatus and Systems. IRE is planning to issue group *Transactions* as satellite publications serving the need of specialists, with *Proceedings* remaining the central official organ. Similarly in AIEE, *Electrical Engineering* will remain the central organ.

AIEE takes pride in its adherence to democratic procedures. It feels its District and Section organization allows it to adhere closely to the tradition of democracy of administration that the Institute has fostered since its foundation; consequently, since the war it has continued to go to its membership with problems of administration brought about by its increase in size. Among the questions answered by the membership was one concerning the main purpose of the Institute. A survey showed the membership overwhelmingly of the opinion that its prime purpose and service lay in the purely technical field. The professional activities for which responsibility is spread through out engineering need the broad attention and interest of the National Society of Professional Engineers, the Engineers Joint Council, or the ECPD.

THE FUTURE

THE COURSE of AIEE seems well marked. In its comparatively brief history it has taken a major part in the development of the kind of civilization that holds the greatest hope for mankind. In less than a century it has instilled a fair amount of electrical knowledge into the mind of every member of the citizenry. It has fostered the education and development of professionals in its field. It has provided a free forum for the presentation, and adoption or rejection, of any new idea in electrical engineering. Its future lies in accelerating the advancement of the art at an even faster pace than in the past.

The tremendous spread of knowledge and understanding of electricity, its characteristics, its supply and application, encompasses a kind of intellectual accomplishment unparallelled in history. The housewife with her electric kitchen, the schoolboy building his ham radio-transmitter, the farmer with his electric milker or hay drier, the mechanic on an electrified production line, the broker trading Oregon shingles for Maine pulpwood, the movie director, the race-track operator, all know well how to use complex electric systems to their greatest advantage. Rheostat and ammeter, short circuit and high voltage, are words or phrases with greater common acceptance than, for instance, the thills and sills, hack crossbar and fore, of the Deacon's "Wonderful One Hoss Shay." The great common public takes for granted engineering processes that were pure fantasy a few years ago.

The colleges and universities, founded on this continent to provide spiritual and political leadership for the expanding community, have added another aim, the development of a professional skilled in the management of materials as well as leadership of men. This attention to the physical has changed mightily the trend of community progress but has done so within the framework of freedom and liberty which was the inspiration of the republic's founding fathers. The Jeffersonian aim of a free rural economy retained its vitality through the continuing expansion of a geographic frontier. The same dream of a free economy for liberty-loving individuals is provided by the ever-expanding and ever-expandable intellectual frontier uncovered by the engineer. The man behind the plow has been replaced by the man behind the slide rule.

AIEE is proud of the leadership it has shared with its sister societies. It joins those societies in celebrating the Centennial of Engineering. It looks forward to a second century of co-operation and progress.

Dimming of Fluorescent Lamps to Increase Their Versatility

A practical system for dimming fluorescent lamps smoothly and efficiently, something the lighting industry has been striving for since the inception of fluorescent lighting, was announced and demonstrated at the annual technical conference of the Illuminating Engineering Society.

By means of the new light control system, developed by General Electric Company lighting engineers at Nela Park, Cleveland, Ohio, the brightness of fluorescent lamps now can be controlled merely with the turn of a knob, just as smoothly and easily as incandescent lamps have been dimmed or brightened in the past, thus greatly increasing the range.

This system consists of a dimming control unit and especially designed matching ballast. Although the equipment is still in the design stage, early release for production is anticipated.

General Electric's Specialty Transformer and Ballast Department will produce the control system. It will be available for use with either the conventional 40-watt preheat type of lamp, or with the new 40-watt "Rapid Start" fluorescent lamps. Two sizes of controls will be made, one operating up to eight lamps, the other to 35.

By means of a circuit which maintains the starting voltage but changes the current to affect the light output, fluorescent lamps can be turned on instantly at any point in the dimming range. By twisting a knob the lamps may be dimmed from maximum brightness until they produce practically no light at all, and then may be brightened in the same manner.

A Turns Index for Pulse Transformer Design

H. W. LORD
MEMBER AIEE

DESIGNERS OF POWER TRANSFORMERS and distribution transformers have a guide number to use in starting their first design. This is expressed by the equation $V_t=K\sqrt{kva}$ where V_t is the volts per turn to use in starting the first design; K is a constant which may vary between relatively narrow limits; and kva is the kilovolt-ampere rating of the transformer.

Pulse transformers are relatively new members of the transformer family. No such guide has been available to the designers of these transformers, hence the design procedure has involved a large amount of cut and try.

Figure 1 shows the equivalent circuit of a pulse generator, pulse transformer, and a resistive load. Switch SW opens and closes to impress pulses of the order of microseconds upon the primary of the pulse transformer as represented by L'_2, R'_e, L'_1, and C'_d.

Pulse transformers usually are constructed with single-layer primary and secondary windings. With such a configuration, both L'_1 and C'_d are approximately proportional to the spacing between the coils. Since L'_1 is approximately directly proportional to this spacing and C'_d is inversely proportional to this spacing, then their product is approximately constant, thus eliminating this spacing as a preliminary design parameter. The core loss represented by R'_e is usually such as to make R'_e so high in value that it can be neglected. Inductance L'_2 of a pulse transformer is related linearly to certain core dimensions, core material properties, and to the square of the secondary turns.

Successful pulse transformer designs have ratios of core dimensions and coil dimensions which fall within relatively narrow limits. By assuming certain ratios between these core and coil dimensions which represent the average of usual practice, it becomes possible to generalize the design relationships to such an extent that all of the coil and core dimensions are eliminated from preliminary considerations. The only parameter left is that of the turns of the windings. By referring all values to the secondary winding, the secondary turns can be made a function of the performance requirements and properties of the dielectric and magnetic materials available for use in pulse transformers. The article shows that for a step-up pulse transformer of ratio greater than 3:1 this parameter relationship is as follows:

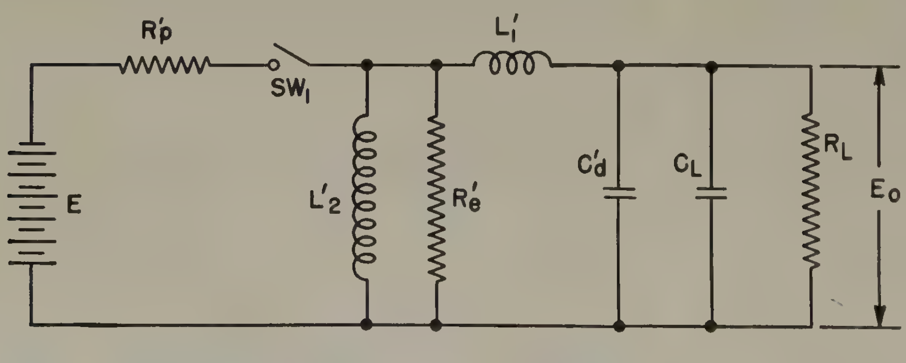

Figure 1. Equivalent circuit of power source, pulse transformer, and resistive load

$$N_s=\sqrt{\frac{10\Delta B\sqrt{L'_1C'_d}}{\mu_p I'_m\sqrt{k}}}$$

where

N_s = secondary turns

ΔB = flux density change during pulse (lines per square inch of gross core area)

L'_1 = total leakage inductance referred to secondary (microhenrys)

C'_d = distributed capacitance of secondary (micromicro-farads)

μ_p = pulse permeability of core under conditions of B and desired pulse width

I'_m = primary peak magnetizing current at end of pulse as referred to the secondary (amperes)

k = dielectric constant of insulation between primary and secondary

Of these parameters, ΔB, μ_p, and k are properties of materials. Values for L'_1, C'_d, and I'_m are determined by the required performance specifications of pulse width, pulse rise time, droop across the top of the pulse, secondary pulse voltage, load resistance, and load shunt capacitance. Methods for making such determinations have been published and are familiar to pulse transformer designers. Pulse transformer designers may use this equation as a guide or turns index to start the first design.

The validity of this guide was checked by using actual pulse transformer design calculation sheet data to obtain values for ΔB, L'_1, C'_d, I'_m, μ_p, and k. These were used then in the turns index equation to obtain a calculated value for N_s, which then was compared with the secondary turns used for the actual design. The designs chosen for this check covered a range of pulse widths from 0.05 to 10 microseconds and secondary voltages from 15 to 100 kv. In spite of deviations from idealized dimensions, the check was excellent.

Digest of paper 52-125, "A Turns Index for Pulse Transformer Design," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE North Eastern District Meeting, Binghamton, N. Y., April 30–May 2, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Electric Systems in the New York Port Authority Bus Terminal

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The distribution system for house and tenant power and lighting including the heating, ventilating, air conditioning, plumbing, sprinkler, and snow-melting systems, elevators, moving stairs, signs, interior and exterior lighting, and the control, communication, and signaling systems which include the public address, clock, bus dispatching, bus counting, fire alarm, and sprinkler supervisory systems, as well as the watch engineer's supervisory control system, are discussed.

THE MAGNITUDE and scope of the electric installation in the $24,000,000 Port Authority Bus Terminal make it difficult to discuss the various systems in detail in a single article. Only those aspects which are deemed of more than usual interest, or discussion of which is considered helpful to others who may encounter similar design problems, will be covered in some detail in this article.

For orientation, a brief description of the Port Authority Bus Terminal is in order. It is the largest bus terminal in the world, designed and built by the Port of New York Authority to provide a convenient, efficient, and attractive terminus for the thousands of commuter and long-distance travelers who enter and leave the City of New York every day on interstate busses. The building, 200 feet wide by 800 feet long, is shown on the cover of this magazine. Made up of six levels, as shown in Figure 1, it occupies the entire block between 8th and 9th Avenues and 40th and 41st Streets, 1 block from Times Square. Twenty-six hundred long- and short-haul busses a day, making a total of 5,200 trips carrying 125,000 passengers, are served by the terminal. These busses formerly occupied numerous terminals scattered about the midtown area and a marked improvement in mid-Manhattan traffic has been achieved. About 85 per cent of the busses using the terminal do not touch Manhattan streets at all but travel to and from the terminal on overhead ramps connected directly with the plazas of the Lincoln Tunnel. Unprecedented in design and function, the structure is a combined transportation terminal, shopping center, parking area, and office building; each has its characteristic problems and requirements.

The electric systems in the Bus Terminal may be divided into two parts: 1. The distribution system for house and tenant power and lighting, including the heating, ventilating, air conditioning, plumbing, sprinkler, and snow-melting systems, elevators, moving stairs, signs, interior lighting of public and tenant areas, and exterior lighting of the ramps, parking roof, and building façades.

2. The control, communication and signaling systems,

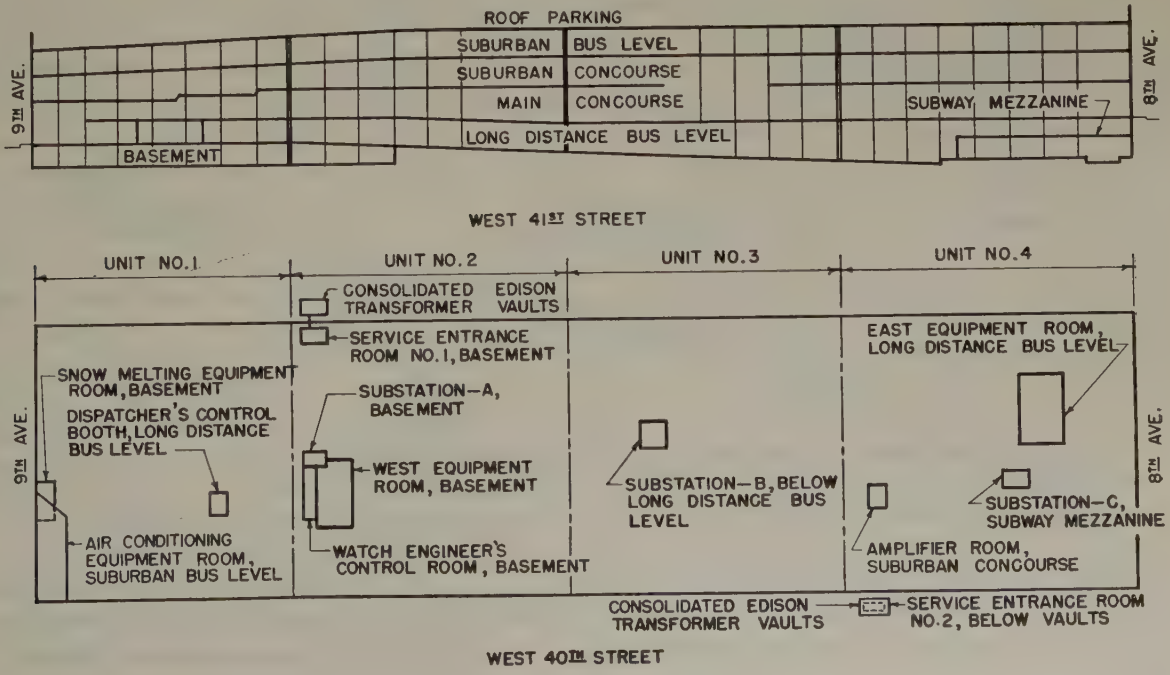
ROOF PARKING
SUBURBAN BUS LEVEL
SUBURBAN CONCOURSE
MAIN CONCOURSE
LONG DISTANCE BUS LEVEL
BASEMENT
SUBWAY MEZZANINE
9TH AVE.
8TH AVE.
WEST 41ST STREET
UNIT NO.1
UNIT NO.2
UNIT NO.3
UNIT NO.4
CONSOLIDATED EDISON TRANSFORMER VAULTS
SERVICE ENTRANCE ROOM NO.1, BASEMENT
SNOW MELTING EQUIPMENT ROOM, BASEMENT
DISPATCHER'S CONTROL BOOTH, LONG DISTANCE BUS LEVEL
SUBSTATION—A, BASEMENT
WEST EQUIPMENT ROOM, BASEMENT
EAST EQUIPMENT ROOM, LONG DISTANCE BUS LEVEL
SUBSTATION—B, BELOW LONG DISTANCE BUS LEVEL
SUBSTATION—C, SUBWAY MEZZANINE
AIR CONDITIONING EQUIPMENT ROOM, SUBURBAN BUS LEVEL
WATCH ENGINEER'S CONTROL ROOM, BASEMENT
AMPLIFIER ROOM, SUBURBAN CONCOURSE
9TH AVE.
8TH AVE.
CONSOLIDATED EDISON TRANSFORMER VAULTS
SERVICE ENTRANCE ROOM NO.2, BELOW VAULTS
WEST 40TH STREET

Figure 1. Longitudinal cross section of Port Authority Bus Terminal and key plan of principal electrical rooms

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Revised text of a conference paper recommended for publication by the AIEE Committee on Industrial Power Systems and presented at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952.

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which include the public address, clock, bus dispatching, bus counting, telephone, fire alarm, and sprinkler supervisory systems, and the watch engineer's supervisory control system for the control and indication of all important electric and mechanical installations in the building.

POWER AND LIGHTING DISTRIBUTION SYSTEM

Basic Design Considerations. Basic considerations which influenced the design of the distribution system are:

1. *Electric loads.* The first consideration in the electrical design, after the functional and architectural requirements of the building were established, was the determination of approximate electrical demands and their geographical distribution. Initial loads were estimated from the following assumed values:

Lighting in bus lane and concourse areas 3	volt-amperes per square foot
Lighting on parking roof . . 0 . 4	volt-ampere per square foot
Lighting on ramps . . . . 0 . 2	volt-ampere per square foot
Lighting and power in tenant areas 8	volt-amperes per square foot
House power (based on predicted motor ratings) 1	kva per horsepower

A demand factor of 1.0 was used for lighting and 0.7 for house power and an over-all diversity factor of 1.1 wa applied. A 35-per-cent allowance in basic system capacit was made for growth.

The total ultimate maximum demand was accordingl estimated at 3,000 kva. Monthly billings, after 1 year o operation, indicate a coincident 30-minute demand o 1,500 kw, or approximately 1,800 kva. The opening of th remainder of the tenant areas and the imposition of othe loads, such as that of the snow-melting equipment, whos full impact has not yet been felt, are expected to increase th maximum demand to about 2,100 kva, allowing about 4 per cent for growth in the building's 50-year expected life

2. *Utilization and distribution voltages.* The large percentage of lighting and small motor loads, especially i tenant areas, indicated utilization at 120/208 volts, 3-phase 4-wire. Due to the large amounts of power involved, distribution at a higher voltage, such as 4,160, was considere but was shown to be uneconomical because of the doubl transformation required, as well as the high rental value o the space transformers and associated equipment woul occupy. Thus distribution at the lower supply voltage wa chosen in spite of the heavy main feeders required.

3. *Number and locations of service entrances and substations* For structural reasons, the building is divided into four 20 by 200 foot units by expansion joints. Each unit is treate individually with regard to power and lighting distributio

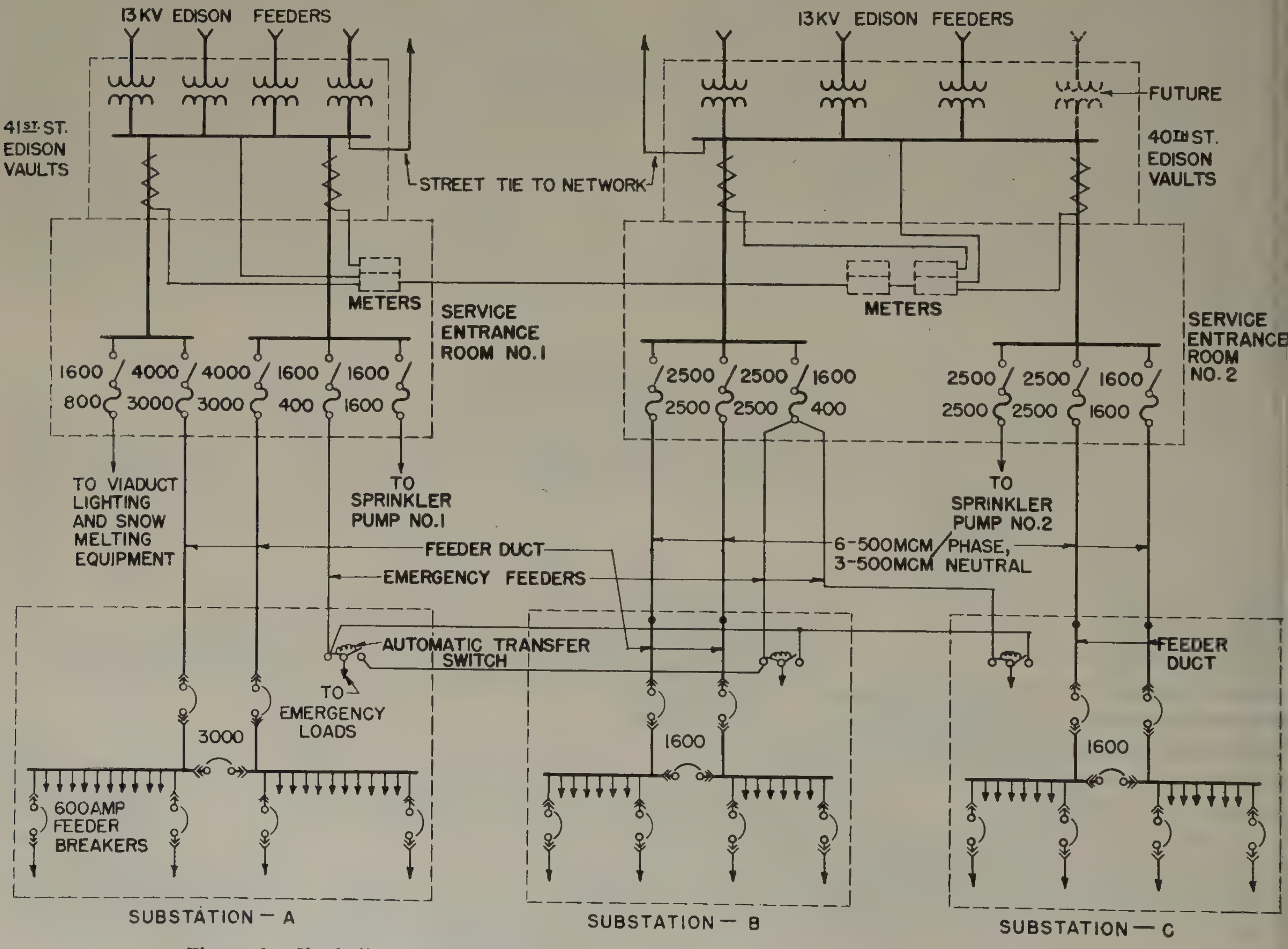

Figure 2. Single-line diagram of electric distribution system at Port Authority Bus Terminal

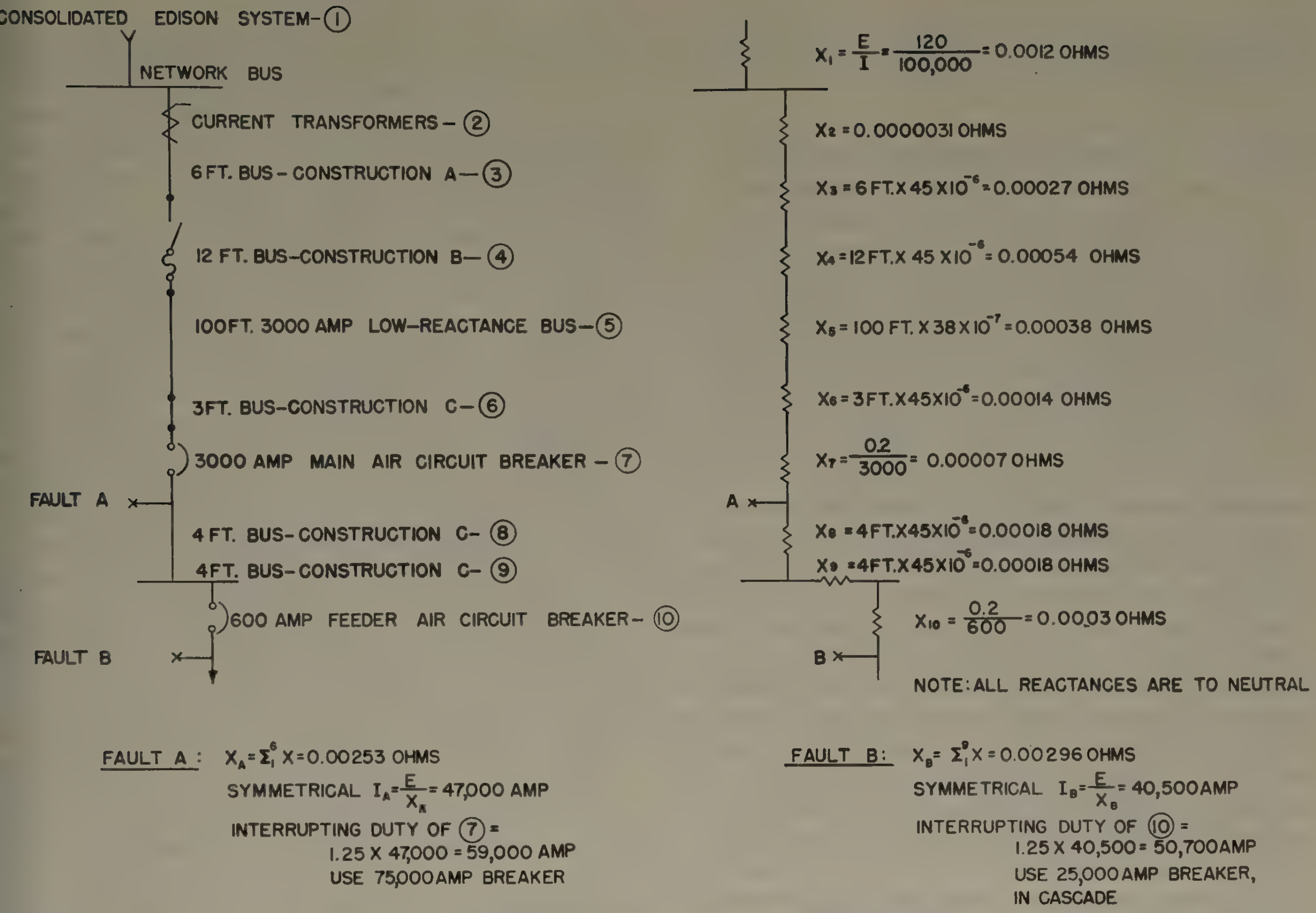
CONSOLIDATED EDISON SYSTEM-①
NETWORK BUS
CURRENT TRANSFORMERS-②
6 FT. BUS-CONSTRUCTION A-③
12 FT. BUS-CONSTRUCTION B-④
100 FT. 3000 AMP LOW-REACTANCE BUS-⑤
3 FT. BUS-CONSTRUCTION C-⑥
3000 AMP MAIN AIR CIRCUIT BREAKER-⑦
FAULT A
4 FT. BUS-CONSTRUCTION C-⑧
4 FT. BUS-CONSTRUCTION C-⑨
600 AMP FEEDER AIR CIRCUIT BREAKER-⑩
FAULT B
$X_1 = \frac{E}{I} = \frac{120}{100,000} = 0.0012$ OHMS
$X_2 = 0.0000031$ OHMS
$X_3 = 6$ FT. $\times 45 \times 10^{-6} = 0.00027$ OHMS
$X_4 = 12$ FT. $\times 45 \times 10^{-6} = 0.00054$ OHMS
$X_5 = 100$ FT. $\times 38 \times 10^{-7} = 0.00038$ OHMS
$X_6 = 3$ FT. $\times 45 \times 10^{-6} = 0.00014$ OHMS
$X_7 = \frac{0.2}{3000} = 0.00007$ OHMS
A
$X_8 = 4$ FT. $\times 45 \times 10^{-6} = 0.00018$ OHMS
$X_9 = 4$ FT. $\times 45 \times 10^{-6} = 0.00018$ OHMS
$X_{10} = \frac{0.2}{600} = 0.00,03$ OHMS
B
NOTE: ALL REACTANCES ARE TO NEUTRAL
FAULT A: $X_A = \Sigma_1^6 X = 0.00253$ OHMS
SYMMETRICAL $I_A = \frac{E}{X_A} = 47,000$ AMP
INTERRUPTING DUTY OF ⑦ =
1.25 X 47,000 = 59,000 AMP
USE 75,000 AMP BREAKER
FAULT B: $X_B = \Sigma_1^9 X = 0.00296$ OHMS
SYMMETRICAL $I_B = \frac{E}{X_B} = 40,500$ AMP
INTERRUPTING DUTY OF ⑩ =
1.25 X 40,500 = 50,700 AMP
USE 25,000 AMP BREAKER,
IN CASCADE

Figure 3. Partial single-line diagram and corresponding reactance diagram, illustrating compution of symmetrical short-circuit currents in determining circuit breaker interrupting ratings

and a separate service "take-off" from the network is provided for each unit, two from each of the transformer vaults located as shown on the key plan, Figure 1. The 1-line diagram, Figure 2, illustrates the basic distribution system.

Although it was originally intended to install a separate switchboard in each building unit, space considerations dictated a combined switchboard *A* for units 1 and 2, retaining, however, the basic concept of a service take-off for each unit. It may be noted that the actual locations of the substations were dictated as much by the necessity of integrating them into the architectural design and meeting the practical problems of installing conduit runs through limited spaces as by purely electrical design considerations.

4. *Fault currents and interrupting capacities.* The Bus Terminal is located in a high load-density area of the Consolidated Edison network. Short-circuit currents of the order of 100,000 amperes ultimately may be available at the network busses in the transformer vaults. A careful fault current study was indicated to assure adequate, but not excessive, interrupting capacity in the design.

The basic location plan having been determined as outlined, and a secondary selective radial system chosen as offering a high degree of reliability and simplicity of operation at a relatively low cost, a fault current study was made. A specific arrangement of switches, busses, cables, and circuit breakers was assumed, reactance values assigned to the various elements of the circuit, and the fault currents at the switchboard main and feeder circuit breakers computed. Figure 3 shows a typical single-line diagram and its associated reactance diagram from a network bus to the load circuit breakers on a distribution switchboard. The reactance of the utility system from the network bus to the generating station was included in the computation at 0.0012 ohm, based on the symmetrical 3-phase short-circuit current of 100,000 amperes at 120 volts. Other reactance values were obtained from manufacturer's data or from reference 1, whose methods were used. A typical fault current computation for the determination of circuit breaker interrupting ratings is carried out on the reactance diagram. In this computation, the motor contribution to the fault current was ignored due to long motor feeders and the relatively small amount of motor load, less than 50 per cent of the total load. Resistances were also ignored; it is anticipated that actual short-circuit currents will be somewhat less than the calculated values.

Due to the large number of switchboard feeder circuit breakers required, it was deemed desirable to cascade them with the main circuit breakers, saving $25,000 in equipment costs and considerable space.

5. *Reliability of service.* In a public transportation terminal serving upwards of 130,000 travelers and shoppers a day, public safety, as affected by reliability of electrical

service to the public areas of the building, is a major design consideration. Factors in the electric installation which contribute to a high degree of reliability are:

A. Service from the utility network at two underground transformer vault installations fed, initially, by seven and, ultimately, by eight 13-kv feeders and connected to the low-voltage network at two points.

B. A separate emergency distribution system supplied directly from two service switchboards and equipped with automatic switches which transfer loads to the alternate supply upon failure of the preferred supply.

C. Automatic "1-shot" reclosure of the main circuit breakers on the switchboards.

D. Electrical and key interlocking of switchgear.

6. *Tenant requirements.* Considerable space in the terminal is devoted to tenant areas whose initial and future use could not be predetermined. Therefore, it was necessary to incorporate a high degree of flexibility in the design of the distribution system to these areas.

Service Entrance Switchgear. Service switches are conventional dead-front 3-pole 250-volt pressure type equipped with dural type *X* fuses and designed to withstand and interrupt 100,000 amperes of short-circuit current. To prevent their operation under load, they are interlocked with associated circuit breakers, switches, or controllers by key or electrical interlocks, the type depending upon the equipment being supplied. For emergency, an extra key is provided in a "break-glass" box at each key-interlocked switch.

Main Feeders to Substations. The main feeders from Service Switchboard Number 1 to Distribution Switchboard *A* are 3,000-ampere low-reactance feeder ducts in nonventilated aluminum enclosures and are designed to withstand mechanical stresses resulting from short circuits of 75,000 amperes.

The main feeders to Distribution Switchboards *B* and *C* are partly cable and partly feeder duct. Each cable run consists of six 500,000-circular-mil polychloroprene-jacketed rubber-insulated cables per phase and three 500,000-circular-mil cables in the neutral, with seven cables in each of three 5-inch asbestos-cement ducts. Final connections to Switchboards *B* and *C* are made by short runs of 1,600-ampere feeder duct in expanded sheet-steel enclosures. These ducts, too, are designed for 75,000-ampere stresses.

Distribution Switchboards. Distribution switchboards in the three substations are metalclad, equipped with drawout air circuit breakers. Each switchboard has two main circuit breakers, each supplying a main bus, with a normally open tie-circuit breaker between busses, all key-interlocked to prevent the closing of both main and tie-circuit breaker at the same time. The main circuit breakers are also key-interlocked with the service switches as previously described. All feeder circuit breakers are rated 25,000 amperes interrupting capacity; main and tie-circuit breakers are rated 75,000 amperes interrupting capacity on Switchboard *A* and 50,000 amperes on Switchboards *B* and *C*.

An unusual feature of these switchboards is "1-shot" automatic reclosure of the main circuit breakers for automatic service restoration upon main circuit breaker tripping caused by a feeder fault in excess of the interrupting rating of the cascaded feeder circuit breaker. Should the main circuit breaker open on a switchboard bus fault, it would lock itself out after one reclosure and tripout; on the other hand, if the fault is in a feeder (and in excess of the instantaneous trip setting of the main circuit breaker), the feeder circuit breaker will remain open but the main circuit breaker will reclose, restoring service to the other feeder circuit breakers on the same bus section. Lower magnitude faults will be cleared by the individual feeder circuit breakers without operation of the associated main circuit breaker.

House Power and Lighting Distribution. The distribution equipment for normal house power and lighting consists of fused convertible distribution and power panelboards and circuit-breaker-type lighting panelboards, located throughout the building and supplied from Switchboards *A*, *B*, and *C*. Sprinkler pumps, snow-melting equipment, viaduct lighting, and the separate emergency light and power system are supplied directly from the service switchboards. House lighting panelboards in public areas are sectionalized and equipped with remote-control switches to permit control of lighting from the watch engineer's control board. Emergency light and power are distributed through fused distribution panelboards and circuit-breaker-type lighting panelboards feeding emergency lighting, exit lights, alarm systems, the public address system, and other critical loads.

Tenant Power and Lighting Distribution. Tenant light and power are distributed through tenant metering panelboards located in electrical rooms and tenant panelboards in the tenant areas. The tenant metering panelboards were designed to afford a high degree of flexibility in circuit rearrangement as changes are made in the sizes of tenant areas. Each consists of: 1, a fuse pullout and watt-hour meter section, and 2, a thermal circuit breaker distribution section. The busses of the distribution section are equipped with removable links permitting pairs of circuit breakers supplying a given tenant area to be on one meter.

House Lighting and Controls. Lighting in the Bus Terminal could well be the subject of a separate article. A brief outline only will be given here. Hot-cathode fluorescent lighting in recessed troffers is installed in concourse areas; incandescent lighting is used in areas such as bus lanes, storage areas, and for roof and façade floodlighting, while sodium lighting is used on the ramps to the Lincoln Tunnel Plaza. Light intensities are generally of a high order, averaging 18 foot-candles in concourse areas and 4 foot-candles in bus lanes. High-intensity transitional lighting is provided at the bus entrances to the long-distance and suburban bus levels. Illumination intensities in public areas may be controlled from the watch engineer's control board, either by turning entire fixtures off in a definite pattern, as in the bus lanes and the suburban and main concourses, or by lighting one, two, or three lamps in the 3-lamp fluorescent fixtures, as in the long-distance concourse. Emergency lighting fixtures are identical with normal lighting fixtures and are integrated into the ceiling patterns, differing only in the use of emergency circuits.

CONTROL, COMMUNICATION, AND SIGNALING SYSTEMS

In addition to the auxiliary systems usually installed in a commercial building, such as watch engineer's controls, telephone, clock, paging, and fire alarm systems, the Bus Terminal contains two unique systems: the bus dispatching system and the statistical bus counting system.

Watch Engineer's Control Board. The watch engineer's control board in the watch engineer's office provides central control and indication of important equipment installed throughout the terminal and may be called the heart of the control, indication, and alarm systems. The board is made up of several sections: 1. lighting control panel, 2. indicating panel, 3. motor control panel, 4. annunciator and trouble panel, 5. heating zone control panel, and 6. heating and air-conditioning panel.

1. The *lighting control panel* permits remote control and indication of house lighting in public areas. Each of 40 switches mounted on the panel controls one of two remote-control switches installed in each of 20 remotely controlled house lighting panelboards. An illuminated-message-type annunciator, mounted above each switch, indicates the lighting panelboard number and section which are controlled. The annunciator lights when the remote-control switch is closed and is so wired that it supervises the control circuit, including the coil of the remote control switch.

2. The *indicating panel* shows the operation of certain items of equipment, such as water and vacuum pumps, entrance heating fans, and air compressors, whose operation is automatically controlled by thermostats, float switches, or pressure switches. In general, auxiliary contacts installed in the controllers of the supervised equipment provide the indication. Where such auxiliary contacts are not provided, the pilot-light connections are made to the load side of the controller and resistors are used where necessary to reduce the voltage applied to the lamps.

3. The *motor control panel* permits remote control and indication for toilet fans and the suburban and long-distance bus level ventilating fans.

4. The *annunciator and trouble panel* informs the watch engineer of emergency or abnormal operation of any equipment, normal operation of which is vital to the terminal and its occupants. It gives audible alarm and visual indications for such conditions as: 1. Emergency shutdown of the turbine-driven air-conditioning machinery; 2. Excessive steam pressure at the pressure-reducing stations; 3. High levels in the drainage and sewage sump pits; 4. Trouble in the snow-melting equipment.

When an alarm condition occurs, a horn sounds and a red and white message appears on the panel. The horn is silenced by operation of a switch and the message changes to red. When the trouble is cleared, the horn again sounds and the message changes to white. Silencing the horn restores the circuit to its normal condition.

5. The *heating zone control panel* regulates the temperature setting in each of the seven zones of the low-pressure steam, vacuum-return system of radiator heating. Each zone control includes an outdoor thermostat which, acting through a variator on the panel, operates the steam valves, thereby regulating the flow of steam to each zone.

6. The *heating and air-conditioning panel* contains a multipoint temperature indicator and a multipoint pressure indicator which enable the watch engineer to check the operation of the heating and air-conditioning systems throughout the building and make the necessary adjustments to maintain comfortable temperatures. Temperatures at 15 locations are transmitted to the temperature indicator by the use of 3-wire resistance thermometer bulbs. Pressure indications for steam lines and vacuum indications for vacuum pumps are transmitted as far as 1,000 feet from the indicator by transducers.

Clock System. The clock system is electronically supervised by means of a high-frequency signal transmitted over the electric distribution system. This system was selected for the following reasons: (*a*). No separate system of conduit and wire is required, (*b*). A clock can be added by merely connecting it to any lighting or receptacle circuit, and (*c*). The initial setting of the clocks need not be "to the second" as they automatically synchronize hourly.

Equipment for producing the high-frequency signal used for regulating the system includes a master clock, and several electronic transmitters connected directly to the switchboard main busses. On the 58th minute of every hour, the master clock sends a supervisory impulse to the electronic transmitters which, in turn, transmit a high-frequency signal over the entire electric distribution system and thereby to the clocks.

The indicating clocks, whether they have continuously moving hands or are of the minute-impulse type, are synchronous motor operated, an adapter in the minute-impulse clocks performing the conversion to minute-impulses. An electronic receiver in each clock receives the hourly signal and causes the clock to respond as follows:

1. If the clock is on time, it continues normal operation.
2. If it is less than 55 seconds fast, it pauses at the next minute until the exact time for resuming operation.
3. If it is less than 59 minutes slow, it resets itself to the exact time at 60 times its normal operating speed.

Upon power failure, the master clock will continue to run for a period of 12 hours by means of a motor-wound spring movement. The individual clocks will stop running upon power failure, but upon restoration of power after an outage of 59 minutes or less, will automatically restart and, on the 58th minute, automatically reset themselves. Should a power outage last for more than 59 minutes, all clocks can be reset from the master clock by manually closing the "electronic-advance" switch for as many minutes as there are whole hours to be recovered. The remaining fraction of an hour is automatically recovered.

Fire Alarm and Sprinkler Supervisory Systems. The Bus Terminal is equipped with a comprehensive system of local and central office fire alarm and supervisory services whose functions and operation are

1. *Local sprinkler signal and alarm system.* The operation of any sprinkler head in either the wet- or dry-pipe systems, or the existence of abnormally high or low air pressure in the dry-pipe systems, actuates an annunciator located in the watch engineer's office. Local air pressure switches, set to operate before the switches associated with the central office system, permit the engineer to remedy the trouble before the signal is transmitted to the central office.

2. *Central office sprinkler supervisory and alarm system.* This

system transmits signals indicating the following to an outside service organization's central office for appropriate action:

A. Operation of a sprinkler head.
B. Operation of supervisory or tamper switches on valves associated with the sprinkler system.
C. Operation of supervisory devices indicating high or low air pressure in the dry-pipe systems.
D. Operation of power supervisory relays on the line and load sides of the sprinkler and standpipe pumps.
E. Operation of supervisory devices indicating low water pressure in the mains between the pumps and sprinkler valves and standpipe risers.

3. *Central office manual alarm and gong system.* The operation of any of the manual fire alarm boxes located throughout the building causes a distinctive coded signal to be transmitted to the central office and to sound only on presignal gongs in selected Port Authority areas. If a general alarm is needed, it may be sounded on the general alarm gongs in public areas by use of a special key in the alarm box.

Snow-Melting System. During stormy winter weather, continuous use of the ramps leading to the suburban bus level and the roof parking areas is assured by a ramp heating system, which prevents the accumulation of snow and ice by circulating a warm fluid through piping in the concrete slabs. Slab temperatures are measured, and the system controlled, by thermocouples, strategically located in the concrete ramps. Upon starting the system, to reduce thermal shock to the concrete slabs, the rate of rise of slab temperature is regulated by a motorized cam time-pattern controller through pneumatic steam valves. Once the correct temperature is reached, it is maintained constant in a similar manner, in accordance with the heat demand of the slabs.

Public Address System. The public address system serves four functions: (*a*) Announcing bus arrivals and departures, (*b*) Paging, (*c*) High-fidelity reproduction of music and (*d*) Warning of excessive steam pressures.

Microphones and control panels are located in the main dispatcher's booth, in the information booth, and in the superintendent's office. Keys on the control panels enable the announcer to select the zones of the building to which the announcement is to be made. At the information desk, a built-in record player is provided with controls so that music can be broadcast over the concourse area speakers. A total of 195 loudspeakers, of five types suited to their acoustical environment, is installed in the terminal.

Bus Dispatching System. The bus dispatching system enables the dispatcher to control the flow of busses to and from the 40 bus berths and the auxiliary platform on the long-distance bus level entirely from the main dispatcher's booth. It performs the functions of bus detection, assignment, delay, and release by means of treadles, relays, pilot lights, berth number signs, and an assignment sign. The dispatcher, sitting at his control desk near the entrance, is unable to view the entire bus level but must, nevertheless, know which berths are occupied in order to make proper berth assignments. A treadle, arranged to close a circuit on the control desk when operated by the rolling action of a bus entering a berth and open the circuit when the bus leaves, performs the function of bus detection through its associated relays. Berth assignments are made by means of an assignment sign at the entrance. The sign, of the "carriage-callboard" type, is controlled from the desk and is designed to display the assigned berth number for the guidance of the incoming bus driver. It is equipped, in addition, with a red "stop" light and left and right directional arrows.

The control desk contains all the relays for the system. A "mimic" panel on the front of the desk indicates the relative locations of the bus berths and contains the necessary switches and indicating lights. Under normal operating conditions, with a dispatcher on duty and no busses in the berths, the indicating lights on the control desk are out and all switches, except the "time-delay" and "stop-light" switches, are in the "off" position.

When a bus enters the terminal, the driver sees the red traffic signal on the assignment sign and stops. The dispatcher assigns the bus by operating the respective switch on the desk. The yellow indicating light for that berth lights, indicating that an assignment has been made, the traffic light goes out, the berth number appears on the assignment sign, one of the directional arrows lights, and the berth number sign goes on. The bus then proceeds to the right or left, as directed by the arrow, to its berth.

After a time delay, the number on the assignment sign goes out, the traffic signal lights, and the sign is set for the next assignment. Upon reaching its berth, the bus rolls over the treadle, causing the berth number sign and the yellow indicating light on the desk, to go out and the red indicating light to operate, showing the berth is in use.

To delay the departure of the bus, the dispatcher places the respective switch in the "delay" position, lighting the red lamp in the berth number sign and the yellow indicating light on the control desk. When the bus leaves the berth, it operates the treadle and puts out the red indicating light on the control desk, indicating that the berth is no longer occupied.

During "off-hours," with no dispatcher on duty, the berth number signs of berths to be used are turned on from the desk and the traffic signal is put out, permitting drivers to proceed directly to selected berths.

Statistical Bus Counting System. A complete statistical record of the departures of bus and other vehicles is kept on a printing recorder actuated by treadles installed at the exits of the two bus levels and the roof parking area.

Departures from each of five lanes are counted and recorded individually, by axles, on a single tape. The equipment distinguishes between forward and reverse movements of the vehicles over the treadles and counts them separately, recording the date and the time to the minute by means of a time unit tied in with the electronic self-regulating time system. A totalizing print is taken automatically every hour but may be taken at any time by pressing a button.

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1. Electric Power Distribution for Industrial Plants, AIEE *Standards Publication Number 952*, January, 1945.

Rapid Measurement of Thermal Resistivity of Soil

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THE EFFECT OF the thermal resistivity of the soil on the temperature of a buried cable is well known. It is of more importance for the newer directly buried and pipe-type installations in which the temperature rise through the soil forms a larger percentage of the total temperature rise than is the case with the older concrete-duct types.

Laboratory methods of measuring the thermal resistivity of soils along a cable route are unsatisfactory because of the expense and the difficulty of obtaining an "undisturbed" sample. The well-known method of field determination using the steady-state temperature rise of a buried heated body is accurate but expensive and too slow for a survey of a proposed cable route. An inexpensive cast-aluminum sphere developed for this purpose reduced the construction cost but the labor involved in taking readings was still prohibitive.

However, a rapid "transient" method of measuring the thermal resistivity of the soil now is available. This is based upon the fact that the rate of temperature rise of a heated body, as well as the ultimate temperature rise, will depend upon the thermal resistivity of the material in which it is buried. This method has been developed from an idea put forth originally by B. Stalhane and S. Pyk in 1931.[1]

The results obtained with this apparatus were compared with the results obtained by the steady-state buried-sphere method and were found to agree closely enough for practical purposes.

The apparatus used consists of a 1/4-inch steel tube approximately 8 feet long. The bottom 5 feet of this tube contain a heater and four thermocouples placed at 1-foot intervals. In use, this long tube or "needle" is thrust into the ground and allowed to reach temperature equilibrium with the soil. The heater is then connected to a battery and a constant power input is maintained while readings of the temperature of the thermocouples are taken at intervals of 30 seconds for 25 or 30 minutes. These temperature readings are plotted against time on semilog paper, see Figure 1. A straight line is drawn through the points from about 10 minutes to 30 minutes and the thermal resistivity is calculated from the slope of this line by multiplying by the factor $4\pi L/2.303\, p$, where p is the power input of the needle in watts, and L is the length of the needle in centimeters. This gives the thermal resistivity of the soil in thermal ohm-centimeters (degrees centigrade-centimeters per watt).

In some cases the accuracy of the method may be improved by a graphical correction procedure. Although poor contact with the soil was feared as a possible source of error, no difficulties have been traced to this effect.

The size of the soil sample is of interest. It is not accurately definable but it appears that in the usual run of soils, the size of the sample seen by each of the thermocouples is of the order of 3 inches in diameter and 6 inches long. Thus, even with a common heater, each of the thermocouples gives a value for the thermal resistivity at its particular depth. This allows the resistivity at different depths to be measured during a single 30-minute run. It is believed that the size of the sample may be increased by continuing the measurements for a longer time. This is limited, however, by the end effects of the needle becoming important.

The theoretical basis for this method is not as sound as is desirable and work is continuing on this matter. It is hoped further information can be made available in the future.

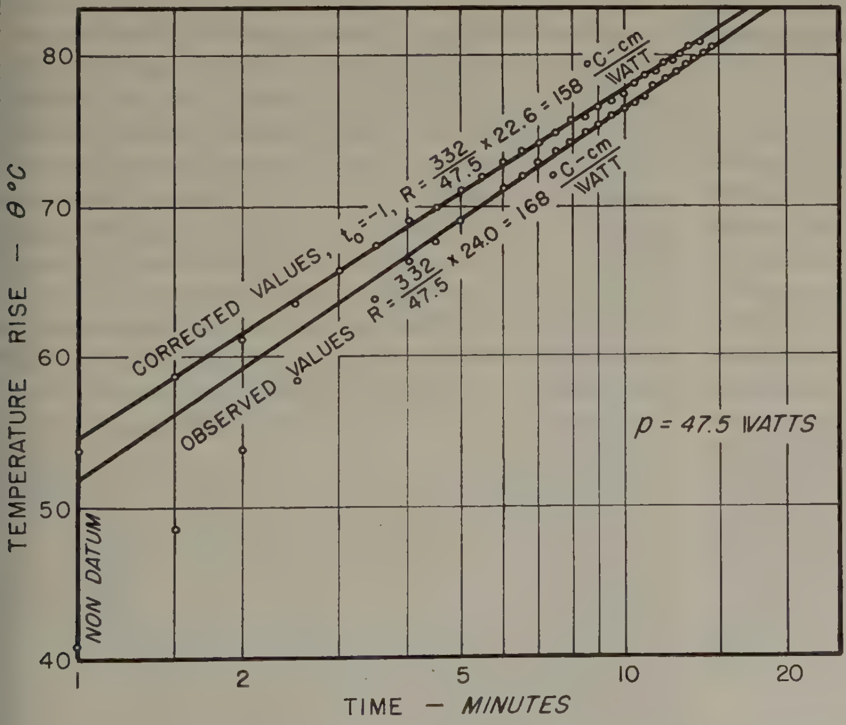

Figure 1. Typical curve of temperature rise versus time on semilog paper

REFERENCE

1. New Method for Determining the Coefficients of Thermal Conductivity, **B. Stalhane, S. Pyk.** *Teknisk Tidskrift* (Stockholm, Sweden), volume 61, number 28, 1931, pages 389–93.

Digest of paper **52-158,** "Rapid Measurement of the Thermal Resistivity of Soil," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions,* volume 71, 1952.

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Electronics, Development, and Industrial Growth

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Developed since the middle of the century of engineering progress marked by the recent Centennial celebration, the electronics industry has shown remarkable growth. This amazing evolution of an industry, however, cannot be attributed to any specific invention or discovery, but to a continuous record of development and research.

THE ELECTRONICS industry has earned the right of a gifted son, the respect due a veteran soldier, and, an ambitious member of the engineering family, it was prominently represented at the recent Centennial of Engineering. It is not in the role of upstart, or merely favored scion, that electronics must be considered, but rather as a promising citizen born and developed since the middle period of this century of accomplishment. Electronics has reached the stature of an essential and vital element in America's defense, in its daily economic well-being, and in the hope for future progress.

An eight-billion-dollar youngster, the electronics industry has come to have wide technical, industrial, social, and even political, implications. It is thus timely and appropriate in this Centennial year to examine the growth record of this amazing product of scientific ingenuity. Where did it come from? Where is it headed? Inevitably our thoughts turn to the inspired early work of the Faradays, Maxwells, and Edisons, men of solitude and genius who gave foundation, perhaps unwittingly, to the team effort that has brought electronics to the fore.

If one studies the developments which have led to today's significant accomplishments in electronics, one salient fact quickly emerges. The real practical electronic developments did not result from any single inventor, invention, or discovery.

The series of experiments and discoveries which led to the De Forest patent of the triode vacuum tube in 1906 covered nearly 25 years. It started in the early 1880's when Edison observed a current passing from the element of his lamps to a floating plate within the vacuum. In 1885 Sir William Preece found that this current depended upon voltage applied between the filament and the plate. In 1891 John Stoney coined the word "electron" to describe a unit negative charge. In 1898 J. J. Thomson measured the charge in the electron. Continued study by others showed that electrons could be released from matter not only by heating, that is "boiling" them out, but by bombarding a surface with light or with other electrons or by drawing them out with a strong electric field. Although Thomson's measurement of the electron was in error by 35 per cent, as later investigators proved, he was close enough to keep the bal rolling. In the early 1900's Leonard, Richardson, an others investigated the conditions surrounding the emission of current from a cathode and J. A. Fleming applie all of this to a simple diod by 1904. De Forest toppe it off with his discovery of th effect of the third element or control grid in 1906 and s the triode was born. Langmuir's work led to the multi-grid tube in 1913. These were perhaps the key component on which electronic circuits are based. Most of this wor was pure research; in the early stages there were no immediate practical objectives or evident uses. It was in fac a laboratory curiosity except for a few trivial applications Langmuir discovered the "space charge" law controllin the flow of electrons in a vacuum, as a side effect, whil studying the performance of electric lamp filaments. Thi discovery made it possible to step up the voltage on D Forest's tube almost ten times and paved the way fo today's high-power broadcasting.

Continuing the march of historical events leading to th birth of the electronics industry, let us consider the background of the gas-filled tube industry of today. The los of electric charge from hot metals was observed by Du Fa as early as 1725. In 1838 Faraday carried on researc with glow discharges. Twenty-two years later Way discovered the mercury arc whose rectifying properties wer first observed 20 years later by Jamin. Between 1890 an 1920 work by Arons, Thomson, and Langmuir resulte in development of the theory of gas ionization by collisio leading to the mercury lamp and mercury vapor-poo rectifier, in glass, with grid control. By 1930 Toulon ha proposed phased grid-voltage control and Housekeepe had developed large-diameter metal-to-glass seals.

Our electronic illumination industry, fluorescent an neon tubing, while depending upon early glow discharg investigations and formulations of gas ionization theory also rests upon work by Plucker in 1859, who discovere fluorescence from ion bombardment.

Back in the early 19th century, following Faraday' discovery (in 1831) that a changing current in one circui set up a current in a remote circuit, Maxwell formulated in 1867, an electromagnetic theory explaining the existenc of electromagnetic waves. Nearly 20 years later, Hert confirmed the existence of electromagnetic radiation an 15 years later Marconi transmitted his first signal. Thi provided the foundation for broadcasting, culminatin today in such developments as the vast microwave lin spanning the continent.

Essential text of a paper, "The Development of Electronics and the Foundation for Industrial Application," presented as part of the AIEE program at the Centennial of Engineering, Chicago, Ill., September 10–12, 1952.

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The author acknowledges the collaboration of Dr. Cledo Brunetti, Beardsley Graham, and W. D. McGuigan of the Stanford Research Institute.

Another backward glimpse shows an equally interesting sequence leading to the development of the cathode-ray tube and electron microscope. In 1875, Sir William Crooks observed the deflection of beams of cathode rays by magnetic and electrostatic fields. In 1895 Braun used these effects in a simple oscillograph, but it was not until 1920 that De Broglie showed that electrons could be considered as waves as well as particles and from this concept, since these waves were much shorter than light waves, it was evident that a microscope could be built with a greater resolving power than was possible with conventional microscopes. In this case the development spanned closer to 80 years because the fluorescent screen on which the electron microscope projects its picture was first discovered in 1859. X-ray tubes also grew out of these discoveries, culminating with Roentgen's insight in 1895. The evolutionary developments of electronics are thus the work of several researchers in different laboratories over a period of decades—in hard, painstaking, and slow development—not the flash of genius of a single discoverer. Note, however, how few of these electronic pioneers are Americans.

All of this combined genius and skill has produced an industry that in not much more than one-quarter century has reached proportions of major influence on American economy. An appreciation of the foundations upon which our preferred living standard is built recognizes such advantages as our diverse natural resources, our capacity in finance, our leadership in applied research, and the amazing applications of mass production techniques. The electronics industry is one of those largely responsible for the fact that the United States, with less than 10 per cent of manpower and land area, has over 50 per cent of the world's most desired products. In its present form, electronics stands both as a major industry in its own right and as a vital support to other industries.

THE APPLICATIONS OF ELECTRONICS

ELECTRONICS IS essential to many industries. The Atomic Energy Commission spent over $50,000,000 for essential electronic controls in 1950 and 1951. The aircraft industry, civilian and commercial, is dependent to a marked degree upon electronics for making aircraft navigation possible under what otherwise would be commercially impossible conditions. The shipping industry likewise depends upon electronics for many of its activities.

The United States now has some 3,000 broadcast stations. The telephone industry, started long before the invention of the vacuum tube, might now be regarded as wholly electronic. The motion picture industry has been revolutionized by sound, automatic processing control, and other electronic advances. Beyond these applications which are largely in the field of communications, electronic developments have opened tremendous possibilities for industrial control instrumentation, information processing, and the analysis and handling of large volumes of information.

In addition to the atomic bomb, electronics has brought about important changes in warfare. The *B-36* depends on some 2,100 vacuum tubes for its navigation and control. The *F-86* would be impractical for many of its operations without the 600 vacuum tubes which it carries. Even this craft is not the ultimate in 1952 war planes. The *F-94* interceptor, equipped for all-weather flying and landing, depends on more than 600 tubes. A modern battleship would be little better than the ones used during the first World War without its nearly 9,000 vacuum tubes.

Ground warfare also has been revolutionized with its handy-talkies, pack sets, beacons for parachute drops, mine detectors, antiaircraft fire control, and proximity fuses. In all, the military has a total of some 15,000,000 tubes operating in several thousand types of equipment.

One measure of the industry's versatility may be seen from the wide gamut which its basic units cover. It commonly handles voltages from 10^{-8} to 10^6 with 10^9 generated and measured occasionally, amperages from 10^{-14} to 10^6, and powers from 10^{-12} to 10^7 watts, all in a range of 10^{12} cycles. It is of interest that these ranges are in about the ratio of the estimated age of the earth, 2 billion years, to 1 microsecond, one of electronics' common time units. Or about the same range as the distance between earth and sun, at one extreme, to the wavelength of the visible light the sun emits at the other.

Of the one million people involved directly or indirectly in today's electronics industry, approximately 360,000 are in manufacturing; of these, 230,000 are concerned with military production, 105,000 engaged in manufacture of radio and television sets, and of the balance the principal number are in manufacturing of electronic parts.

The eight billion dollar industry is divided dollarwise as follows: radio and television manufacturing and sales, broadcasting, and records—$4,000,000,000 per year, retail price; civilian radio servicing—$850,000,000 per year; induction heating equipment—$15,000,000 per year; dielectric heating equipment—$2,000,000 per year; gas and vapor industrial tubes—$13,000,000 per year; industrial vacuum tubes—$50,000,000 per year; photo tubes—$18,000,000 per year; magnetrons and klystrons—$27,000,000 per year; military electronics—$3,000,000,000 per year, manufacturer's price.

The industry's present capacity is 30,000,000 tubes per month, of approximately 1,200 different types; 500,000 television sets per month; 500,000 home radios per month; 100,000 portable radios per month; 300,000 automobile radios per month; as well as several hundred thousand germanium diodes and transistors.

Actual production rates have been running at about 70 per cent of capacity for the past several months. At the present time this adds up to: 19,000,000 television sets using 400,000,000 tubes; 50,000,000 radio sets using 350,000,000 tubes; telephone systems using 3,000,000 tubes; police and fire communications using 1,000,000 tubes; taxi radios with 1,250,000 tubes; aeronautics with 1,000,000 tubes; and perhaps 15,000,000 tubes in military equipment.

Since 1941 greatest progress has been made in developing practical electronic devices and introducing them to industrial practice and processes. World War II provided the first major incentive and marks the debut of the electronic industry as we know it today. Following the war, television and other fields such as industrial and medical instrumentation placed large demands on electronic engineering. Just when a decline in output of the industry was imminent, Korea changed the emphasis back to military electronics with a moderately strong effort continuing in television and other commercial uses. Once the crest of the defense program has passed, can we look for another decline? The majority opinion appears to be that we can expect continued forward drive after some adjustments. On removal of present restraints on materials and operations, civilian production of electronic equipment will rise again. We now have 108 television stations. The unfreezing of television and shift to ultrahigh frequency opens up requirements for transmitters and receivers from hundreds of communities now either not served at all or lacking in sufficient number of stations. The Federal Communications Commission has 716 applications on file and some 2,000 stations are contemplated. We must view the electronics industry as a continuously increasing business. The rate no doubt will vary, but it will remain positive as far ahead as we can see.

In reviewing current developments with an eye to their potential for the future, one must realize the aftermath of disillusionment which can result from contemplating miracle electronic products that may never materialize. We must separate, as accurately as possible, from all those products or developments that are technically feasible, those practical embodiments of useful devices which public demand will force into physical realization and production. We must not mortgage the future though we should not be overly modest in our forecast.

DEVELOPMENT AND RESEARCH

TODAY'S LABORATORIES are more concerned with development than with research. Their principal objectives are improvements in present equipment, further application of existing ideas, and, in some cases, new items. Probably 90 per cent of all electronic engineers are working on improvements—perhaps 50,000 engineers. Some 35,000 of these are concerned with the application of techniques developed during World War II and their modern military or commercial practice. There are probably fewer than 5,000 engineers working on entirely new systems and components.

The pure research which goes on today and is applicable to the electronics industry, may be difficult in many cases to detect and define as such. This is partly because it is just as difficult in the middle of the 20th century to foresee the future as it was to foresee modern electronics from the discovery of the Edison effect in the 1880's. It is also difficult because much of the basic research which will apply to this field in the future may be generated in fields quite unrelated in their present effort; for example, within the realm of physics or mathematics. In fact, 18 per cent of the country's physicists, or 1,200 people, are engaged in electronic activity, and many of the physicists are in applied research, not basic research.

We are led, therefore, to postulate the future of the electronics industry on the basis of applied research, development, and engineering rather than upon the exploratory research which is difficult to evaluate.

The computer of today would not have been possible without invention of the vacuum tube and the crystal diode. As we view the building blocks of today's accomplishments, we see certain needs and problems of industry, and of the public, technically capable of solution by adding these blocks to each other. Development today depends more on economic than technical feasibility.

Many of the military electronics applications cannot be described because of security restrictions. An example, however, was released recently. A need of airplane pilots for decades has now been developed for aircraft, a radar that shows the airplane's location in flight on a map in front of the pilot. Cruising at 200 miles per hour, an airplane so equipped can map details of terrain and weather obstacles as far as 200 miles away. Such radar can be used as a telescope, penetrating the clouds and darkness to give the viewer a close-up of a selected area.

Translation of military developments into commercial applications for air lines now requires only time. There is increasing demand by the public to do something about congestion of air traffic in the vicinity of terminals, especially the "piling up" of airplanes in bad weather. In addition to better scheduling of flights, faster handling in descent is needed. We must by-pass the human pilot and navigator and apply navigational intelligence directly to the controls of the aircraft. Within 5 years we should have a truly all-weather day and night commercial airplane. The number of electron tubes or equivalent to accomplish this is two to three times that now carried aboard the *DC-6B*. Ground equipment will be increased in proportional amounts. Because of the added safety features one can expect the public to use air travel to a much greater extent. It is not unreasonable to predict, therefore, a substantial increase in aviation-electronics alone.

One of the limiting factors in the electronics industry to date has been that of reliability. Most equipment with vacuum tubes operates on an average of perhaps 5,000 tube-hours per failure. A 4-tube household radio might expect to operate a year or so without difficulty. A well-designed television set having five times as many tubes will have a correspondingly greater number of failures. This situation has tended to restrict vacuum tubes to uses where failure can be overcome by alternate methods or to the entertainment field where failures are not serious. Industrial users of electronics have been slow to adopt equipment requiring large maintenance costs and which might hold up production lines without warning, or where dependability is questionable.

Electronics engineers, however, are learning methods of controlling failures which will make equipment relatively independent of environment and still perform its intended purpose. It has been said that the only thing wrong with electronics was the electron tube. With the advent of the transistor, the germanium diode, and the magnetic amplifier, we may remove this stumbling block to the progress of electronics. While the transistor is only about 5 years old and its development, therefore, has barely begun, transistors are already being produced at the rate of several thousand per month and engineers are designing them into countless circuits. It should be only a matter of a few years before they are commonplace in electronic equipment. This child of electronics has created the biggest commotion in the industry since its inception. A complex device? Not exactly in form, but complex in development and fabrication process. In essence the transistor is a small piece of germanium with a few wires connected to it.

The transistor's impact on the industry will be greeted with mixed feelings by some. The device is considered a real threat to the receiver tube business. In the near future it could take over half that business. Its growth may come so fast as seriously to curtail vacuum tube production. Its lower power requirements will change the character of the electronic components market, accelerating the printed circuits business and markedly affecting electronic component designs, size, shapes, and ratings. It may even deteriorate the market for such components as power transformers, batteries, and electrolytic capacitors. In the long run, however, it will open up new uses for electronics and restore the vacuum tube market, even though the latter will probably never regain its position percentagewise.

A degree of reliability quoted for the present transistor is about 15 times that of the average vacuum tube and the fact that it dissipates little heat, which accelerates the deterioration of other components, means the entire electronic system might be 100 times more reliable than was possible with vacuum tubes. Increased reliability gained in this way may well account for a large expansion of the industry by opening up tremendous new possibilities in industrial control and other applications to industrial needs which heretofore have been resisted because of the likelihood of failure of electronic tubes.

Much has been said and glowing analogies made of the modern digital computer, often described as a giant brain. These devices are still crude and their intellectual level is hardly that of an angleworm. Much remains before they can become everyday devices. The large-scale digital computer is in general a device which takes a small amount of information and carries out extensive computations with that information. Other applications of large-scale electronic devices are the electronic information processing systems or accounting machines where a large amount of information has a relatively small amount of computation carried out upon it.

The application of computers to commercial inventory opens up whole new areas of possibilities. Department stores, warehouses, lumber yards, petroleum distributors, and almost every industry with large inventories will soon be asking for such machines. Their use extends much further. The computation of service bills, power bills, bank statements, and many other accounting procedures are ideal applications for electronic information-handling machines. Such machines will serve stock exchanges, tax bureaus, census offices, market analysts, and statistical experts. A single machine can handle accounts receivable and payable, purchases, and inventories. This application of electronic devices alone can be expected to grow into an industry larger than all of today's electronics industry.

These memory devices are capable of storing enormous amounts of information which can be recalled with lightning speed. They extend man's reasoning ability by speeding up his calculations and his processes of deduction. These two factors, extension of man's memory and reasoning, are possibly the most important contributions electronics can make towards accelerating invention and progress in world developments of tomorrow. Not only will the scientist, engineer, and accountant profit, but management is interested in its possibilities for other reasons. Nine million persons, or one out of every six workers, are tied up in clerical activities. Such operations are expensive and produce results slowly so that management's decisions today must be based on data usually as much as weeks or months old. Electronic information-handling machines will place data at the fingertips of the executives, complete and up-to-the-minute.

OTHER FACTORS

But electronics does not stop here in its aid to science and industry. Continued development of improved types of transducers means that scientific and industrial measurements will be speeded up with sensitivity and range multiplied manyfold. Few physical phenomena can escape the eyes of electronic detectors. For example, the thermistor detects minute changes in temperature fast enough so that in combination with an amplifier-bridge it can feed control signals to the heat source to keep the temperature constant within very narrow limits. In the factory of tomorrow, most of the quantities pertinent to acceptability of the output product will be metered instantaneously and monitored continuously so that optimum quality will be derived and defective products or material held to an absolute minimum. Increasing labor costs, the production of more and better products for living, and the need to make the best use of every bit of our raw material resources, make it almost mandatory that industry turn to automatic factories. There is need for closer and more intensive collaboration between the industrial machine designer and the electronics engineer if we are to realize the full benefit of electronics.

Miniaturization of electronic equipment, reducing its size and weight, is a factor which is expected to have great influence on the growth of the electronics industry. An enumeration of developments attendant to miniaturization that mark a stepping-off point for better things to come include, in addition to the transistor, new ferromagnetic materials, tantalum capacitors, boro-carbon resistors, magnetic and dielectric amplifiers, titanate dielectrics, printed circuits, silicones and polytetrafluoroethylene, allyl and epoxy resins and plastic embedment, hermetic sealing, new ideas in heat transfer, and fiber glass products. In the aircraft field, passenger comfort, cabin pressure, temperature, and humidity are all dependent on accurate electronic equipment. Both comfort and safety are limited by the size and weight, as well as reliability, of electronic devices. Each pound allotted to electronic aids is paid for in decreased aerodynamic performance. If all the possible safety devices are to be added to an airplane, there would be no room for payload. Every extra hundred pounds carried by commercial aircraft represents an annual loss in equivalent revenue of close to $20,000. This is one reason why miniaturization research and engineering is receiving strong emphasis.

While we continue to use war as a means of settling international disputes, we long for the day when it will take a dormant place with such practices as cannibalism and slavery, cast aside by civilized people. This will come to pass when the people of the world, through increased association with each other, will come to understand that the prosperity of their fellowmen has an important bearing on their own. This closer understanding of each other's problems will stem from two important contributions of electronics, better communication and faster transportation.

Though we tend to regard military research as a necessary but undesirable expenditure, we are heartened in that much of the money is being dedicated to accelerated progress in communication and transportation. Government research often sets the pace for industry. In communication we now know optimum frequencies on which to transmit for long-range communication. We also have automatic means for selecting frequencies and for keeping transmitters and receivers in tune. This background, added to experience gained in Voice of America broadcasts, will develop in the normal process of events into world-wide broadcasting. Its influence no doubt will be felt strongly in international politics. It well may become the United Nations' most effective device for advancing its program through education of the world population.

Knowledge being created in the development of long-range guided missiles and supersonic aircraft presages for the not-too-distant future 1,000-mile-an-hour speeds with accurate navigational guidance to any spot on earth. These developments are so completely dependent on electronics that the vehicles could not otherwise leave the ground. Even aerodynamics development is being accelerated, in fact made possible, by electronic devices that extend the testing area from a ground mount to full speed tests in the air with instantaneous recording of performance at the ground through new developments in telemetering. When the time arrives that we are in daily contact with foreign countries by international television and can travel by airplane to any country in a few hours, we will have made a major contribution to eliminating war.

Although the fluorescent light business has flourished, we are still not content with its low efficiency of converting electric to light energy. Though much more efficient than the incandescent lamp, it still wastes over 70 per cent of the power. Daily advances in the generation of cold light, like the transistor and solid rectifiers, are based upon work in solid state physics from which much is expected in the future. These methods of going directly to the molecular or atomic structure of solids for the harnessing of electronic phenomena may prove to be the leads to better and more efficient lighting.

While one series of developments made possible our present industrial rectifier and control tube industry, the development of high-power transmitting tubes made possible the induction and dielectric heating installations of today, which in numbers of large electron tubes used surpass those in all communication purposes combined.

Rectified alternating current, such as that produced by the mercury-arc rectifier, is used for production of aluminum, magnesium, zinc, chlorine, sodium hydroxide, hydrogen, and hydrogen peroxide, as well as all electroplating processes. Another large user of mercury-arc rectifier power is the traction industry, particularly the New York subways. Present-day developments indicate ever-increasing uses of the electrolytic refining methods deriving their power electronically and keeping pace with the ever-widening use of the light metals.

In forestry, agriculture, and food processing, electronic sorting, weighing, and packaging are now routine. As more is learned about existing possibilities, the electronic industry will be called upon to supply them. We need subsoil moisture instrumentation for automatic control of irrigation, more efficient methods for determining the ripeness of fruit in order to select the proper time for picking, better watchguards in forests automatically to detect and radio the locations of fires, and better reporting of abnormally high levels in rivers. Two-way miniature radios are yet to be applied extensively in directing operations in lumber areas, orchards, and quarries, because formerly they were too large and heavy. Today's research has reduced the size materially, however.

Although much wealth has come from our natural resources, thousands of square miles of potentially rich unexplored land and coastline lie within our nation's boundary. Prospecting is an expensive business and a slow and tedious operation even when the lands are accessible. Large areas are without suitable roads and are hard to reach. To cart in heavy, expensive exploration equipment, not knowing whether anything fruitful will result, is definitely beyond consideration. Electronics has entered this field in many capacities, principally as instrumentation, measurement, or detection. It is now also believed possible to combine expendable electronic telemetering devices and air-blast seismic waves operating from an aircraft for exploring normally inaccessible areas for oil and other underground resources. The method would do for geophysical exploration what the air-borne magnetometer has done for mineral location. It would not be necessary to set foot in the area unless the tests indicate the presence of valuable deposits.

The atomic power field is based on the nuclear reactor which, as a producer of heat, can be used to drive prime movers. One pound of fissionable material contains as much energy as 1,300 tons of coal. Unlike the atomic bomb, the nuclear reaction releases this energy slowly and within the control of an operator. Direct release of this energy as an electron current, without heat as an intermediate step, is an anticipated development.

Atomic power plants require a large amount of electronic control and instrumentation equipment. Because of the large amount of radioactivity generated in its operation, workers cannot come near the unit. An atomic plant must be equipped with completely automatic control devices of the self-regulating type. We look to this area for a substantial and increasing demand for electronics.

Lawrence B. Lessing, an editor of *Fortune* magazine, has given an account of the industry's future, which is even more optimistic than one might gather from most electronics engineers. It is growing, he says, at a rate of two to four times every 10 years. To maintain such an expansion, an industry must expand about 10 per cent per year. Presumably then, at least a 10 per cent effort of our development staff devoted to new devices (for which there is a foreseeable demand) would be adequate to maintain the rate of expansion.

Present expenditure for research in electronics is about $325,000,000. This represents only 11 per cent of the total research expenditure in the nation. Out of this sum, 28 per cent is spent in government, 63 per cent in industry and industrial research organizations, and 9 per cent in universities. About 17,000 electronic engineers are active in research development and another 600 scientists on university staffs are active in this field.

The increasing number of scientists and engineers, although inadequate in number for the potential and possible expansion, are better trained than those of a generation ago to bridge the gap between a scientific discovery and its practical application. It is probable, therefore, that the elapsed time, which averaged perhaps 30 years in the early development of the industry, from an invention to its practical application, will be reduced to something closer to 5 to 10 years. This trend will tend to accelerate expansion.

Any growth of Government monopoly of research and development must be limited lest it choke off the basic research upon which new industries are founded. Today, two-thirds of all the research dollars come from the Government and are allotted mostly for military research. Faced with the pressing commitments of a military situation, it is easy to overemphasize the development of gadgets rather than research which can most benefit industry and the public.

IMPORTANCE OF RESEARCH

Looking over today's outstanding developments in the light of earlier discoveries, we find they came first from scientific fact-finding research. This was followed by application of new knowledge to new products and processes designed to meet the needs of the day. They have not come from the lone inventor, but from teams of scientists of many professions working together toward a common objective. The electronics engineer of today turns to the chemist, physicist, metallurgist, ceramist, and others for assistance in designing electronic equipment. He looks to the industrial economist for guidance as to whether his development is practical from an economic standpoint. Management leans on research as a means of insuring company stability in the future by finding new products, improving quality, and cutting costs. The number of electronic developments and the growth of the electronics industry has been almost completely dependent on, and has kept an even pace with, research. This is characteristic of all modern industries, many of the largest of which are completely dependent on manufacturing products which did not exist a couple of decades ago. One of the most valuable parameters used by investment analysts in determining where funds should be invested for the least risk is the proportion of total sales dollars spent for research. It is clear that as research goes, so goes the industry.

Certain signs on the European horizon carry a message we might well heed. Recently, while leading a technical mission of the Organization for European Economic Co-operation, the author was impressed with the fact that, faced with shortage of raw materials, countries like Italy and England are turning their interest to products requiring a large amount of engineering rather than bulk processing. Weak in two of the three principal methods of creating wealth, mining and agriculture, these countries are turning to the third method, manufacturing. Raw materials can be imported, submitted to extensive, value-increasing processing, and sold at a high price. With little lumber, crude oil, or steel to sell, England is emphasizing development of such products as jet engines, automatic industrial processing machinery, and high-quality electrical components. The premium is on brains and research rather than materials and brawn.

This type of talent and development is not the monopoly of the United States. Generated by necessity and fed by the need to maintain a favorable balance of world trade, this activity will produce competitors we cannot disregard. Our own ability to compete in world markets with highly engineered products will depend on the attitude and support industry gives research. Furthermore, we too may soon lack raw material.

With the impact of electronics and its companion developments, atomic energy and jet propulsion, the world finds itself at the crest of a technological surge exceeding the effect of the Industrial Revolution (1750–1850). The reverberations of the Industrial Revolution were being felt at the beginning of the 100 years represented by the Centennial of Engineering. The impetus forcing the curve upward is the "push-pull" combination of man's needs providing the "pulling" and his ambition, creative spirit, and ingenuity the "pushing." It cannot be stopped. Man's mind will be freed to continue to explore the unknown, reinforced with tools that cut time into microseconds. Though this will no doubt bring new and difficult problems, we hope and believe it will lead to a perfection of living exceeded only by that of the power that has made all these things possible.

Although recurring situations seem to impose upon each new generation a complex of problems requiring unique solutions, it has been shown through the ages that most of the pressures and burdens on mankind are relieved or respond eventually to the applications of science.

Born just 500 years ago and faced with the problems imposed by *his* environment, Leonardo da Vinci, one of the greatest geniuses and most versatile men of all time, clearly saw the importance of basic and applied research when he said:

"Studia prima la scienza e poi sequita la pratica nata da essa scienze."

"First study science and then follow the practice born out of that science."

Evaluation of Capacity Differences

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MANAGEMENT IS faced frequently with the problem of selecting the most desirable plan from several possible alternatives which affect system capacity. Comparison of the various proposals may reveal differences in several respects in addition to the amount of system capacity, such as the time and amount of capital investment required, the relative service reliability of the different plans, and their simplicity or flexibility. This article deals with two particularly troublesome questions that arise when alternative plans differ in plant capacity supplied or required.

CREDITS FOR EXCESS CAPACITY

ALTERNATIVE PLANS often differ in the amounts of capacity provided. It is sometimes pointed out that the plan which in some years supplies a greater excess over actual requirements thereby provides improved reliability of service and more insurance against unpredictable loads, machine failures, drought, and similar contingencies. Accordingly, that plan is preferable on several counts which do not appear in the cost analysis. Therefore, it may be argued, the economic comparison is unfair unless credits for these advantages are inserted into the cost comparison.

A careful review of the fundamentals of economic comparisons indicates the error in this proposal. The purpose of an economic study is to compare the present worths of future revenue requirements under alternative plans of action. It is not essential that the alternative plans accomplish identical objectives, so long as any one would be acceptable.

In problems of the foregoing type, three familiar steps are involved: 1. a tabulation of total system investment in each year under each plan; 2. a tabulation of the corresponding annual costs (=revenue requirements) in each year under each plan; and 3. a statement of the present worth of these annual costs of each plan.

Step 3 supplies the whole answer to the economic problem; the plan having minimum present worth of future annual costs is the cheapest. Other plans may have advantages other than in cost; the two aspects must not be confused.

COST OF ELECTRICAL LOSSES

THE COST of supplying electrical losses is treated conveniently as the sum of two components: 1. the energy component, or costs to generate the incremental loss kilowatt-hours; and 2. the demand or power component representing the annual carrying charges on investment in incremental plant required to supply the peak loss in kilowatts.

The literature displays extreme variations in the estimate of item 2. Usual textbook approach is to assume average costs per kilowatt of capacity, just as in establishing rates for any load. Some engineers, however, argue persuasively that the small loads represented by loss kilowatts do not affect plant installation programs; if the installation program is the same regardless of losses, then the demand component is zero.

Actually, the correct estimate must be the same as would result from applying the 3-step year-by-year approach just described. In order to reproduce that procedure, it is necessary to scrutinize carefully five factors that are often given inadequate consideration:

1. The nature of ideal capacity savings, and the effect of standard unit sizes of equipment.
2. The effect of the time-discount factor (step 3 of the basic approach).
3. The importance of incremental versus average unit costs of plant.
4. The probability that ideal savings actually will be realized, as affected by the size of the loss differential.
5. Allowances for load diversity and for losses in the supply facilities intermediate between generating source and the losses to be evaluated.

Having established the annual cost of losses in dollars per year, it is a common and convenient practice to "capitalize" them. Because this operation is so seldom performed correctly, it is necessary to describe some popular but inaccurate methods. One such is the practice of adding the capacity cost of losses directly to the first cost of the transformers, without first reducing it to an annual expense, and adding the "capitalized" energy component. Another fallacious proposal is the suggestion that losses be evaluated in terms of lost revenue, ignoring the fact that incremental losses do not result in lost revenue, but actually signify additional revenue if the rate of return is to be maintained. Also, the statement occasionally made that the economic choice depends upon the accounting procedure of the company is not true and lacks any foundation in fact.

The wide range of opinion that is characteristic of the evaluation of capacity differences probably evinces a misunderstanding of the arithmetic involved more often than profound differences in personal judgement. It is believed that the difficulty can be resolved best by meticulous observance of the truism, with all of its implications, that the purpose of an economic study is to compare the present worths of future annual revenue requirements under alternative plans.

Digest of paper 52-12, "Evaluation of Capacity Differences in the Economic Comparison of Alternative Facilities," recommended by the AIEE Committee on System Engineering and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Past and Present Forms of Electric Apparatus in Physical Medicine

F. T. JUNG

The emphasis is placed on recurrent concepts underlying entire groups of nonacceptable electric devices to try and save potential manufacturers and users from further disappointment. In addition, the article helps focus attention on problems in need of further research.

THE INFORMATION presented in this article has been gathered in the hope that it may not only save time and money for manufacturers of electric apparatus for medical use, but also that it may save some human beings the misery of continued treatment with ineffectual, unsafe, and inconvenient apparatus. In addition to this negative purpose, however, the facts adduced may serve the positive purpose of suggesting interesting problems still to be attacked.

The term "Physical Medicine" means the use of physical (as distinguished from chemical) agents in the diagnosis and treatment of disease. It is convenient and enlightening to contrast the use of such chemical agents as the antiseptics, antibiotics, and anesthetics with the use of such physical agents as heat and cold, massage and manipulation, electric currents, and ionizing radiations. The American Medical Association recognized the importance of this second group when it created the Council on Physical Therapy in 1925. It had become clear that, in the battle of man against disease, physics had as much to contribute as chemistry. It was also clear that in the selection and purchasing of physiotherapeutic equipment the physician was often confronted with technical questions much too complicated for him to answer without the help of experts. One of the primary purposes of the Council was to offer advice to physicians in this situation. A procedure was gradually developed whereby the Council arranged for the physical and clinical testing of physiotherapeutic apparatus. A list was kept of apparatus that had been found effective, safe, convenient, and durable, and inclusion of a device in this list was announced in *The Journal of the American Medical Association.* The announcement in *The Journal* included a description of the device with a statement of the claims that legitimately could be made for it. At intervals of about a year an up-to-date edition of the list was published in a booklet called "Apparatus Accepted."

It was soon realized that physical apparatus was as important in the diagnosis of disease as it was in its treatment. In recognition of this fact the name of the Council was changed in 1945 to The Council on Physical Medicine. In 1949 the words "and Rehabilitation" were added as a reminder of the fact that much of the modern program of rehabilitation depends on the use of physical apparatus such as hearing aids and artificial limbs.

The work of the Council soon took on a double aspect, the positive one of accepting that which was good, and the negative one of "not accepting" what was bad. Some apparatus on the market was so very bad that merely omitting it from a list of accepted apparatus clearly was not sufficient to warn the public and the profession. It had to be rejected, and with some emphasis. As a result there has accumulated through the years a list of announcements, published in *The Journal*, which gives the reasons for rejecting a given apparatus as ineffective, unsafe, inconvenient, or poorly made. Often the reason given for nonacceptance is that the advertising was misleading or the methods of promotion objectionable. It is easy to see that the one objection generally implied the others: Bad promotional methods were necessary only for ineffective, unsafe, inconvenient, or poorly made apparatus, and the abandonment of unreasonable claims for an apparatus was no misfortune to a manufacturer if there was a residue of well-justified claims on which to base his advertising.

One of the tragic things about the list of nonacceptances as one goes over it, is the fact that sometimes the same unhappy idea underlies a whole series of forms of apparatus. Manufacturers ignorant of the history of medical apparatus are attracted by certain favorite ideas, which constantly recur. For this reason it should be helpful to study these recurrent ideas.

STATIC DISCHARGE THERAPY

ONE RECURRENT IDEA long antedates the life of the Council, but is especially instructive. It concerns the use of discharges from Leyden jars and from generators of static electricity. The story can be told in part in the words of Benjamin Franklin. The following is quoted verbatim from a letter written by him December 21, 1757, that is, more than 17 years before the outbreak of the American Revolutionary War:

> Some years since, when the news-papers made mention of great cures performed in Italy and Germany, by means of electricity, a number of paralytics were brought to me from different parts of Pennsylvania, and the neighbor-

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ing provinces, to be electrified, which I did for them at their request. My method was, to place the patient first in a chair, on an electric stool, and draw a number of large sparks from all parts of the affected limb or side. Then I fully charged two six-gallon glass jars, each of which had about three square feet of surface coated; and I sent the united shock of these through the affected limb or limbs, repeating the stroke commonly three times each day.

The first thing observed, was an immediate greater sensible warmth in the lame limbs that had received the stroke, than in the others; and the next morning the patients usually related, that they had in the night felt a prickling sensation in the flesh of the paralytic limbs; and would sometimes shew a number of small red spots, which they supposed were occasioned by those pricklings. The limbs, too, were found more capable of voluntary motion, and seemed to receive strength. A man, for instance, who could not the first day lift the lame hand from off his knee, would the next day raise it four or five inches, the third day higher; and on the fifth day was able, but with a feeble, languid motion, to take off his hat.

These appearances gave great spirits to the patients, and made them hope for a perfect cure; but I do not remember that I ever saw any amendment after the fifth day; which the patients perceiving, and finding the shocks pretty severe, they became discouraged, went home, and in a short time relapsed; so that I never knew any advantage from electricity in palsies that was permanent. And how far the apparent temporary advantage might arise from the exercise in the patient's journey, and coming daily to my house, or from the spirit given by the hope of success, enabling them to exert more strength in moving their limbs, I will not pretend to say.

More than 120 years later, in the early 1900's, the idea of treating disease with static discharges was revived in this country. Large machines standing 5 or 6 feet high, with huge rotating disks, were sold in all parts of the United States. Some of them were still to be seen in the 1920's, standing in the offices of physicians in small towns from Illinois to Arkansas, and gathering dust. They were slow to disappear. When a patient stood upon the glass-legged platform, with the machinery whirring and blue sparks jumping at him from the electrodes, the psychological effect was immense, and patient and physician alike were loath to admit that they were wasting time and money. But critical study yielded no evidence of benefits, nor any good theoretical reason for expecting benefits. The objective, visible effects of static discharges were primarily on the skin.

GALVANIC CURRENT THERAPY

In contrast with static electricity in this respect is the current of much lower voltage but higher amperage now called galvanic or direct current, which has much more striking effects on muscles and nerves than it has on the skin. Galvani's discovery that frog's muscles could be made to twitch was made in 1786, and Volta developed his "voltaic pile" in 1800. The galvanic current proved to have a legitimate use both in the diagnosis of nerve injuries and in the exercising of temporarily paralyzed muscles after such injuries. It also has been put to illegitimate uses by quacks in a curious way. An apparatus exemplifying this was exposed in Chicago within the past 2 years. The patient was instructed to hold an electrode in each hand. The electrodes were purposely made of dissimilar metals and a sufficiently sensitive ammeter was put into the circuit between them. In accordance with the principle embodied in Volta's pile, therefore, a distinct current was registered by the ammeter. The voltage in such an apparatus is determined by the relative position of the two metals in the electrochemical series, but the resistance is determined to a marked degree by the areas of the electrodes and the pressure with which they are held. If one of them is controlled by the quack he can control the readings of the ammeter at will. It would take too long to tell how easy it has been for quacks to impose on patients in this way.

Between the completely rational use and the completely unscrupulous misuse of direct currents there is an intermediate disputed zone. Both direct currents and low-frequency alternating currents can be used to stimulate muscles via their motor nerves. One device rejected in recent years by the Council applies several pairs of electrodes to different parts of the body and stimulates various muscles to contract. The user can lie on a couch without a thought in his head while the apparatus makes his muscles quiver, jerk, and vibrate. The claim was made that this would reduce weight. However, calculations based on the known caloric equivalents of fat easily show that an extraordinary amount of strenuous muscular exercise must be done to get rid of a gram of adipose tissue, and that the light and lackadaisical exercise afforded by these electric muscle twitchers has no weight-reducing effect worth mentioning.

ELECTRICALLY OPERATED VIBRATORS

Among apparatus not accepted by the Council there have been three electrically operated vibrators. One consisted essentially of a motor driving an oscillating mechanism which transmitted a vibratory motion to the user by means of a belt. It was rejected because

1. Volitional effort was not encouraged.
2. The same result could be accomplished without an apparatus.
3. Treating only one part does not give any of the advantages of general exercise.
4. The use of such apparatus is monotonous and the patient loses interest in the treatment.
5. The effect was that of mechanical massage and lacked the physiologic benefits of exercise.
6. The firm's advertising was misleading, exaggerated, and unwarranted.
7. The advertising and descriptive literature did not give adequate warning of certain dangers connected with its use.
8. The name of the apparatus was objectionable.

A similar device was in the form of a cylinder with a conical tip connected with a vibrator. It could be inserted in various orifices where it was supposed to set up an "alternating mechanical stress" to relieve asthma, stimulate nerve function, and induce sleep. It was rejected because the claims in the advertising were unwarranted, misleading, and exaggerated.

A third apparatus of this kind was a vibratory massage unit advertised for the treatment of bladder trouble, impotence, pelvic disorders, insomnia, and so on. It was rejected because of the misleading claims.

These remarks concerning vibrators are not intended to apply to nonmedical uses of vibrators, for instance the use of vibrators by a barber in massaging the scalp. The Council is concerned only when a device is promoted with the claim that it helps to cure disease.

ELECTRICALLY DRIVEN EXERCISE APPARATUS

Another class of apparatus in which there have been rejections is that of electrically driven exercise apparatus. The idea of filling a gymnasium with mechanical equipment like rowing machines and stationary bicycles was at one time quite popular, and a logical consequence was the development of electrically driven equipment such as the mechanical horse. This is not altogether irrational because passive movement has a definite value in physical therapy. However, passive movement lacks some of the benefits of active exercise, and there is obviously a limit to how far a manufacturer can go in claiming benefits for sick people in connection with electrically driven exercisers. This limit has to be defined by qualified experts in physical medicine.

For this reason, some electrically driven exercisers have been accepted, but some others not. One of the nonaccepted devices resembled an operating table; it was equipped with extensions, levers, clamps, and straps, to which the patient, lying on his back, could be fastened securely. Passive exercise was furnished by means of various levers, which were moved or rotated through certain predetermined angles by an electric motor. The Council did not find convincing evidence for the claims that this device would

1. Equalize tension of opposed sets of muscles.
2. Relieve muscular congestion.
3. Improve muscular tonus.
4. Rebuild weak and unexercised muscles.
5. Break down muscular adhesions.

To prove such claims it would be necessary to measure the quantities concerned—to measure the tensions of opposed sets of muscles, the muscular congestion, and the muscular tonus—and to demonstrate the initial existence and the eventual departure of the "adhesions." Since the manufacturer did not and could not supply evidence of this sort, it had to be pointed out that the claims for the apparatus were unwarranted and the apparatus could not be accepted.

HYDROGALVANIC BATH

A curious use of the electric current is in the "hydrogalvanic bath." The patient lies in a tub while electric currents are made to pass through the water. Even if the dangers of shock are eliminated by careful design, there remains the objection that no measurable benefits have been proved to result from the hydrogalvanic bath, and the Council has not accepted apparatus for administering it.

HEAT THERAPY

Six apparatuses for administering heat to the human body have failed to receive acceptance by the Council. This is significant because a much larger number have been accepted, and because heat administered in various ways is certainly one of the most effective and reliable means by which the physiatrist secures his results. One of the rejected devices was an infrared radiator for which unwarranted claims had been made. A second form of apparatus had a curious name suggesting that it would do something to the patient's blood plasma. The pretentious name proved to be misleading, for the apparatus consisted essentially of little more than two cylindrical heating units placed on either side of the patient on a bed. With the proper coverings this made a sort of fever treatment. The methods used to promote it were misleading. A third apparatus was an elaborate apparatus for the heating of various body orifices and consisted of a chromium-plated steel cabinet containing diversified controls and regulators, and a number of varieties and shapes of applicators. It was not accepted because the clinical results obtained with it in the hands of competent investigators did not justify the claims made in the advertising. A fourth apparatus called the Photo-Electric Dilator was designed for insertion into the rectum, where it generated heat that was intended for the treatment of rectal, vaginal, and uterine disorders. The name proved to be misleading because there was nothing in the device that converted light into electricity, and it did not give the remarkable variety of clinical benefits promised by the advertising. A fifth, the Thermo Therapeutor, was not accepted because of crude construction and unscientific and unwarranted claims. A sixth, rejected in 1936, was a crude precursor of the modern electric blanket. It was rejected because it was inconvenient and impractical, because there was no convincing evidence of its safety, and because some of the claims made in the advertising were not substantiated.

ULTRAVIOLET RADIATION

More than 30 sources of ultraviolet radiation have been accepted for various purposes by the Council. Seven have been denied acceptance. Some have been too weak to be useful medically, and some have been sold with exaggerated claims for the benefits to be expected from their use. The confusion of claims has been great, and the claims for benefits from particular wavelengths or bands have sometimes been bizarre and hard to evaluate. The Council has refused to sanction the use of ultraviolet sources for "dual purpose" lighting, the installation of potent ultraviolet sources in offices and schoolrooms where the occupants would be exposed daily to a gratuitous and unmeasured total dosage of irradiation; this was the basis of the rejection in one instance.

OZONE GENERATORS

Related to the ultraviolet generators are the ozone generators. Forty years ago a surprisingly large number of ozone generators became available. It is quite likely that some or all of them produced oxides of nitrogen in addition to ozone. In any case, well-controlled research by physiologists and bacteriologists at the time showed that the gases produced by these generators could not be inhaled safely by people in concentrations high enough to kill the bacteria used as test-objects or to oxidize the odoriferous chemicals chosen for the investigation. Excellent research on this subject was published by Jordan and Carlson and by Sawyer, Beckwith, and Skolfield in 1913. This probably discouraged the use of ozone as an air-purifier for some years, but by 1935 the promotion of ozonizers for use in homes, garages, and so on, reached a second peak. One manufacturer claimed to have made 60,000 installations. The entire subject was reviewed at that time by the National Bureau of Standards with special reference to the claims made by the firm for benefits to be expected by the 60,000 users of their ozonizer. These claims were so ill-founded that the writer of the Bureau's report complained, "It is difficult to comment on the advertisements of this company with restraint. The reader of a series of them . . . would get the idea that the application of ozone . . . was a development of the most advanced and thorough scientific research . . . ." Since that time two devices intended to generate ozone for its supposed medical benefits have been specifically denied acceptance by the Council, and none is on the accepted list at this time. This does not, of course, bar the possibility that ozone generators might be useful for disinfecting or deodorizing spaces from which people can be excluded. When an ozonizer is used in an unoccupied room, it is no longer a question whether it confers medical benefits or whether the gas generated is ozone unmixed with oxides of nitrogen.

HEARING DEVICES

One of the most curious devices ever considered by the Council was a device which produced tones that were intended to stimulate the ears of people with impaired hearing. Listening to this tone was represented as an exercise that would strengthen the hearing. It was rejected for lack of evidence that the supposed improvement could be measured by an audiometer. This is quite a different thing from various devices designed to give people practice in hearing and reproducing speech. Mechanical devices for reiterating sounds, words, and sentences can be extremely time-saving and helpful, and are acceptable to the Council when promoted with well-founded claims. Equally acceptable have been various types of audiometers designed to detect and diagnose defects of hearing.

Some of the finest triumphs of electrical engineering have been in connection with hearing aids. A number of electric hearing aids have been rejected because they were poor electroacoustically, and one because of numerous bitter complaints about advertising. In general, however, the modern American hearing aid is a marvel of ingenuity, and the current list of the Council names 87 accepted hearing aids.

MISCELLANEOUS NONACCEPTED DEVICES

The list of other devices that have not been accepted includes: 1. an apparatus for filling the air with negative ions, the inhalation of which was assumed to have therapeutic effects; 2. a pump for applying positive and negative pressures alternately to the scalp for the prevention and treatment of baldness; 3. a device designed to apply an electric current for the removal of superfluous hair, rejected (though found to be safe and effective) because the advertising policy whereby it was promoted was believed detrimental to the public welfare; and 4. eight forms of diathermy apparatus. Diathermy is a potent therapeutic agent that must not be self-administered; one diathermy apparatus was not accepted because it was promoted for use in the home. Another diathermy apparatus was not accepted because it was promoted with claims for specific and athermal effects. The claim for specific effects was based on the assumption that particular wavelengths would remedy particular diseases or kill particular organisms; this assumption is unproved. The claim for athermal effects was based on a report that some of the beneficial results of diathermy are brought about directly by the electromagnetic disturbance in the tissues even when this is insufficient to generate measurable amounts of heat; this is probably false. The value of diathermy itself is unquestioned today, and the demand for diathermy equipment at present is great enough so that manufacturers need not rely on claims for specific or athermal effects.

ACCEPTED APPARATUS

It is possible that the negative aspects of the Council's work have been too much emphasized in the foregoing. However, the positive aspects can easily be seen by going over the current edition of "Apparatus Accepted."

By way of comment on the apparatus that now stands accepted it might be remarked, first, that such apparatus has clean-cut physical properties and is sold not so much for specified diseases as for specified physical performance. An example is the modern diathermy apparatus, which, if it is to comply with the standards of the Federal Communications Commission, must give some well defined wavelengths and those only.

This fact is also illustrated by the increasing number of infrared generators and other means of applying heat. The effectiveness of warmth properly applied in many situations is so evident that no specific claims for particular diseases need to be made, and the necessary apparatus can be sold simply on the basis of objectively measurable performance. An especially localized application of heat is that called electrocautery or surgical diathermy. Several forms of apparatus for this purpose have been accepted. The Council has also accepted one apparatus for the removal of unwanted hair; it is essentially a device for applying heat to the root of the hair by inserting a very fine electrode into each individual hair follicle.

Secondly, one might remark that the list reflects recent advances in the physiology of respiration and in the control of man's environment. There have been marked improvements in apparatus and methods for artificial respiration. One interesting advance is the introduction of the cuirass type of respirator, which differs from the tank type in covering only the chest and abdomen instead of enclosing all of the body from the neck down. Better understanding of respiration has led to the construction of better incubators for premature babies, better inhalators for first aid, better equipment for inhalation anesthesia, and better oxygen tents with improved methods of regulation, humidification, and refrigeration.

A third point of interest is the increasing emphasis on rehabilitation. This is illustrated most strikingly in the number of accepted hearing aids, and to a lesser extent in some of the apparatus for exercising and retraining the handicapped. Several forms of electric apparatus for stimulating muscles and their motor nerves have been accepted to aid in preventing the atrophy of temporarily paralyzed muscles. The Council has also accepted some electrically driven apparatus that promotes the flow of the blood in a patient's extremities in order to reduce the danger of thrombosis and bedsores.

Accepted forms of electric equipment utilized for diagnostic purposes include electrocardiographs, electroencephalographs, audiometers, amplifying stethoscopes, and oximeters for determining the concentration of oxygen in the blood.

In these remarks some emphasis has been given to the distinction between physical and therapeutic claims. It is comparatively easy nowadays to determine and describe what an apparatus does in a physical sense. But what it does in preventing, diagnosing, or curing a disease is generally a much more difficult question. The difficulty of obtaining convincing clinical evidence is commonly unsuspected by manufacturers. It is not always appreciated by physicians whose training and experience has been confined to the actual practice of medicine. It is not fully appreciated except by those who have tried to reconcile the discordant reports in medical literature and to carry out investigations themselves.

The pitfalls begin with the unfortunate and misleading word "control." To the unsuspecting, a "controlled" experiment would be one that was carefully supervised by someone in authority, or an experiment in which all the variables were given some prearranged values and held rigorously constant at those values. But that is not what "control" means to the clinical investigator. It means a comparative experiment of a sort that has to be done when it is not possible to hold all the variables constant at prearranged values. One compares a treated group with a contratest group that is either not treated at all or else is given some older conventional treatment. Without "controls" in the sense of contratests, clinical research rarely gives convincing results. This is one reason why clinical reports that look good to the manufacturer are sometimes found unconvincing by investigators familiar with the history of medicine, the logic of clinical research, and the baffling behavior of living things. The manufacturer can, however, avoid all these difficulties if he is content to make none but physical (as distinguished from therapeutic) claims for his product.

OUTLOOK FOR THE FUTURE

A CONSIDERATION of the past and the present naturally tempts one to extrapolate into the future, to venture predictions, make out trends, or at least formulate hopes. Several ideas suggest themselves:

1. It is to be hoped that diagnostic apparatus will be developed for the detection of strains. The biological systems exemplified by the human body differ from many inorganic systems in that their response to variations of some factors in the environment within the normal range is not linear. For instance, the temperature inside the body is not a linear function of the temperature of the environment. Within a moderate range of environmental temperatures, the temperature of the body acts like an independent variable. Beyond the normal range the compensatory mechanisms striving to keep a constant internal temperature are strained more and more, but up to some point they are successful. The existence of such striving and strain may be so well concealed that it is unsuspected. It is here that diagnostic methods could be of greatest help. When the point of compensation is passed, however, the defenses of the body may break down quite suddenly. After that diagnosis is easier, but cure is more difficult if not impossible. Refinement of diagnostic apparatus to permit the detection of strains will be an important advance.

2. It is to be hoped that the introduction of new diagnostic apparatus will be preceded by careful testing by methods that have been provided by modern statisticians. This is especially true of complicated electronic apparatus which most users are quite unable to understand, test, or repair. There is an instance of one user who complained that he could not tell when his apparatus was out of order, since it kept on grinding out tracings just the same. If the information given by one diagnostic device is of a sort that cannot be obtained from any other sort of device by way of verification, then the apparatus in question should be used to obtain duplicate readings that can be studied by the statistical test-retest method.

3. Higher degrees of specificity for various radiations may be found. Though early hopes for specific effects for various wavelengths of diathermy were disappointed, it still is possible that in the wide range of vibrations, from audible to ultrasonic, and in the far wider range of electromagnetic radiations, from slow alternating currents to cosmic rays, particular effects may be obtained from particular frequencies.

4. Higher degrees of localization in both diagnosis and treatment may prove possible. In anesthesia, for instance, local administration of a drug is at times much preferable to the general administration. It may prove possible to carry this principle much further in the future. In the past some hopes for improved localization have been disappointed. For instance, it was at one time hoped that sufficient differences might be discovered in the electrical properties of various kinds of nerve fibers so that

the application of an electric current with the proper choice of intensity, frequency, and waveform would enable one to stimulate any desired class of fibers within a mixed nerve. (A motor nerve contains at least six different kinds of fibers, and a mixed motor-and-sensory nerve contains several more. One might wish to stimulate only one kind to the exclusion of the others.) Unfortunately these hopes have not been realized yet, and the results of local electric anesthesia have likewise been disappointing. But when one considers the fineness and speed with which the television apparatus scans its field, for instance, the fineness of the nervous structures in the human body no longer seems so far beyond our reach. Why could not something analogous to the television field be applied to the surface of the human brain at the motor or sensory areas? The idea that this might, for instance, restore some kind or degree of vision to the blind, even after the destruction of eyes and optic nerves, and that direct electric stimulation according to some minute pattern on the surface of the occipital lobes of the cerebrum might be carried out, is a possibility that has been considered by neurophysiologists in considerable detail. The principle could be extended to other sensory structures and to motor mechanisms as well.

Electronic engineering seems to be converging with neurophysiology in several curious ways. Not only has the neurophysiologist been using more and more elaborate electric apparatus in his researches, but he finds more and more analogies between biological and electric systems. Their normal behavior includes taking orders, learning, retaining, forgetting, playback, feedback, and self-regulation. The bundles of wires in a modern business machine strikingly resemble the tracts and trunks of the nervous system. The behavior of the hind leg of a salamander after transplantation into some abnormal position is just like that of a device that has been plugged in wrong; it continues to act as if it had been wired in a certain way and cannot be made to act in any other. The movements of patients with certain diseases of the nervous system remind one irresistibly of the behavior of an automatic elevator that got out of order suddenly after discharging its passenger and went on thereafter opening and closing its door rhythmically. This curious symptom persisted until it was cured by the building engineer.

Speculations based on these facts seem less extravagant, and more within the realm of the possible, as the science and art of electrical engineering continues its amazing progress.

Plastic Pipe Used for Underground Conduits for Power Lines

A 90-degree bend for a post outlet is cemented in this Kingsport Utilities underground conduit installation. The light weight of the plastic pipe permits the men to work in a standing position

Extruded Tenite plastic pipe is being used for the first time as underground conduits for power lines.

In a test project undertaken by Kingsport Utilities, Kingsport, Tenn., in co-operation with Tennessee Eastman Company, trial installation has been made in a Kingsport city block where the power company has put in a 5-light White Way. Tenite pipe in 20-foot lengths was used instead of the regular 5-foot conduit sections made from a compound of asbestos and cement.

The plastic piping for test conduits was selected because its successful use in oil fields and other industries had pointed up its flexibility, ease of installation, corrosion resistance, high impact strength, and light weight.

To prepare trenches when installation work began, the operator of the mechanical ditch digger had only to scoop up clay and shale rock. Because of the flexibility of the pipe, the trenches did not have to have the exact straight-edge sides and base required for the usual rigid type of conduit.

All that was necessary for joining was to brush some thinner to soften the section ends, follow with cement and slip together. After drying for 30 minutes, the joint was as strong as the pipe itself.

It took a 2-man crew only 20 minutes to lay 247 of the 1,100 feet of Tenite pipe used in the project. By comparison, it would have taken 4 hours' work had the regular rigid conduit been laid.

Economics of Distribution-Type Transformers

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THE CONVENTIONAL TRANSFORMER, which predominates in the number of units in service, is protected by high-voltage fuses and lightning arresters that are normally mounted separate from the transformer, while the protected transformer is a packaged unit having, integrally mounted for its protection, low-voltage circuit breakers, high-voltage fusible links, and lightning arresters.

The Westinghouse Corporation, in 1950, conducted a nation-wide survey of electric supply systems representing 17,604,650 meters in which cost and other data were accumulated relative to the performance of these two types of transformers. These results are summarized herein and are supplemented by 1950 figures of Union Electric Company, St. Louis, Mo.

The protected transformer cost usually approximates that of the conventional transformer, plus its protective equipment. However, the cost, in place, of the protected type, because of the package feature usually is less than that of the conventional transformer, due to less pole-top rearrangement expense. This economy of installation was a strong factor in the Union Electric's standardizing on protected transformers in available ratings. Since the installed cost represents the total investment, the interest and amortization costs on the protected type likewise tend to be less than for the conventional type. Items 2 to 5, Table I, give installation costs for the districts showing the lowest and highest values and the average for the nation. Items 8 and 9 give interest and amortization rates. By using these data plus catalogue figures for transformer and other material costs, a comparison of the total installed investment and of the yearly interest and amortization charges may be made.

Table I. Installation, Maintenance, and Annual Costs—1950 Values

Item	Minimum	Maximum	National Average
Costs in Dollars			
1. Crossarm and hardware	2.94	4.07	3.19
Installation of:			
2. Transformer*	12.09	20.43	13.87
3. Crossarm**	1.35	2.75	2.19
4. Lightning arrester**	1.47	2.94	2.15
5. Cutout and fuse**	1.48	2.94	2.17
Replacement of:			
6. Transformerϕ	25.04	36.74	31.80
7. Fuse	5.11	10.97	6.52
Annual Rates in Per Cent			
8. Interest	3.27	8.73	4.62
9. Amortization	3.35	4.85	4.27

* 10 to 15 kva. ** For one of each. ϕ 3 to 15 kva.

The maintenance expense has been broken down into the cost of the transformer failures and of outages. Table II summarizes, in per cent, these two types of troubles, as obtained from the national survey and from the Union Electric's records. By using these data in conjunction with items 6 and 7 of Table I, maintenance costs for the two types may be estimated.

Table II. Operating Data

Transformer Failures, Fuse Outages, and Circuit Breaker Trips in Per Cent

		Transformer Failures					Fuse Outages and Circuit Breaker Trips				
		National Survey			Union Electric of Missouri		National Survey			Union Electric of Missouri	
Type	Cause	Minimum	Maximum	National Average	County*	City*	Minimum	Maximum	National Average	County*	City*
Conv.	Lightning				0.11	0.18				0.52	0.34
Prot.	Lightning				0.00	0.00				0.00	0.00
Conv.	Overload				0.52	0.33				0.12	0.33
Prot.	Overload				0.00	0.00				1.20	1.13
Conv.	Short circuit				0.03	0.07				1.61	1.59
Prot.	Short circuit				0.00	0.00				0.68	1.50
Conv.	Other				0.14	0.37				0.60	0.59
Prot.	Other				0.10	0.00				0.62	1.13
Conv.	Total	0.74	1.41	1.00	0.80	0.95	3.57	8.23	5.64	2.85	2.85
Prot.	Total	0.14	0.40	0.26	0.10	0.00	0.48	2.46	1.02	2.50	3.76

* Based on single-phase 3 through 50 kva—9,739 conventional and 1,925 protected transformers in county; 7,273 conventional and 951 protected transformers in city.

A comparison of the Union Electric's operating records with the national survey shows their conventional transformer failures slightly below the national average and fuse outages lower than the lowest. These outstanding records are due partly to the mounting of lightning arresters on conventional transformer tanks and connecting for 3-point protection as they go through the shop, and partly to their fusing schedule which approximates the protected transformer circuit-breaker trip curves. In spite of this excellent record, protected transformer failures are lower than the lowest survey district, and circuit-breaker trips are somewhat higher than the maximum.

In the Union Electric Company data, overloads caused the greatest number of conventional transformer failures and involved a 1950 expenditure of $17,000.

The total absence of outages on protected transformers from lightning is a direct result of the transformer circuit breaker. The comparatively large number of overload circuit-breaker trips is because Union Electric has no systematic routine for checking signal lights because of a tight manpower situation.

Digest of paper **52-149**, "Economics of Distribution-Type Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Not scheduled for publication in AIEE *Transactions*.

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D-C Drives for Multisection Machines

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The advantages of the individual generator system for most applications of adjustable-speed drives has caused it to be used increasingly for sectional drives. As a result, "packaged" drives for individual sections of machines have become more popular and have increased machine flexibility and simplicity. Several of these typical drives are discussed here.

Much of what we use for everyday living has been poured, extruded, calendered, rolled, or woven on some kind of continuous-flow multisection processing machine. From steel in many forms, through rubberized fabric, plastic sheeting, paper, and cloth, to photographic film, and even cookies, all are products of multisection machines. The American talent for mass production has made the so-called "tandem" drive* an important industrial tool.

Nearly always these machines must operate over an adjustable speed range with automatic co-ordination of speed or tension between sections. Modern-day industrial practice is to use d-c adjustable-voltage drives. A few applications are encountered where other types of adjustable-speed drives are well suited. A-c brush shifting motors, magnetic slip coupling drives, wound rotor motors, adjustable-frequency drives, mechanical-drive steam turbines, and constant-potential d-c motors are a few of the better known of these. However, their use is limited to special cases which will not be discussed here.

On the other hand, application of the d-c adjustable-voltage drive to multisection machines has become common for a variety of processes. Wide speed range and close co-ordination between sections are easily obtained. System flexibility is greatly increased if speed is adjusted by controlling the voltage applied to the motors. The relative speed or tension between sections then can be controlled by adjusting the motor shunt field current. A combination of constant torque and constant horsepower is available to match any load characteristic.

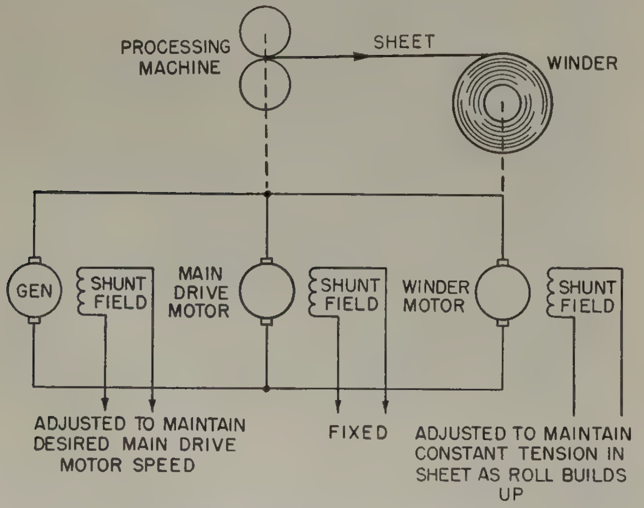
PROCESSING MACHINE
SHEET
WINDER
GEN
SHUNT FIELD
MAIN DRIVE MOTOR
SHUNT FIELD
WINDER MOTOR
SHUNT FIELD
ADJUSTED TO MAINTAIN DESIRED MAIN DRIVE MOTOR SPEED
FIXED
ADJUSTED TO MAINTAIN CONSTANT TENSION IN SHEET AS ROLL BUILDS UP

Figure 1. Schematic diagram depicting a multisection machine for processing and winding up a sheet of material

Figure 1 illustrates a system in which the voltage applied to a processing machine main drive motor is adjusted to set the speed of the machine. The motor of a center-driven winder is supplied from the same generator and thus tends to maintain a speed proportional to the machine speed. By adjusting the shunt field strength of the winder motor, torque can be made to change to maintain constant tension in the sheet as the roll builds up. This also reduces motor speed to compensate for the increase of roll diameter.

The electrical engineer has the choice of providing power for the multisection adjustable-voltage machine through a single generator, common to all the motors, or through individual generators with one to a motor. He even may use a combination of the two systems, grouping most of the motors on one generator for instance, with a separate generator for another motor. In either case, speed of the machine is varied by adjusting the voltage supplied to the motors, and extra speed range is available by adjusting the motor shunt fields.

The advantages of the individual generator system has led to its increasing use for sectional drives. It is the purpose of this article to show that an outgrowth of this trend is the greater use of "packaged" drives for the individual sections of multisection machines, with consequent further gains in flexibility and simplicity. An examination of several typical drives will illustrate the unit-drive aspect of the individual generator system, and will show how packaged adjustable-speed drives easily fit into place.

THE INDIVIDUAL GENERATOR SYSTEM

It is generally recognized that the separate sections of a processing machine will remain in approximate speed correspondence when the d-c motors are supplied from a common power source. Adjustment of the common voltage provides control over machine speed, and speed of one section relative to the others can be adjusted by changing the shunt field strength of the driving motor. The seeming simplicity of this arrangement and past economic factors have often influenced the engineer to select this arrangement, and hundreds of such drives are in service today.

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* Other names given to multisection machine drives are sectional drives, train drives, range drives, and co-ordinated drives.

Revised text of a District paper recommended for publication by the AIEE Committee on General Industry Applications and presented at the AIEE North Eastern District Meeting, Binghamton, N. Y., April 30–May 2, 1952.

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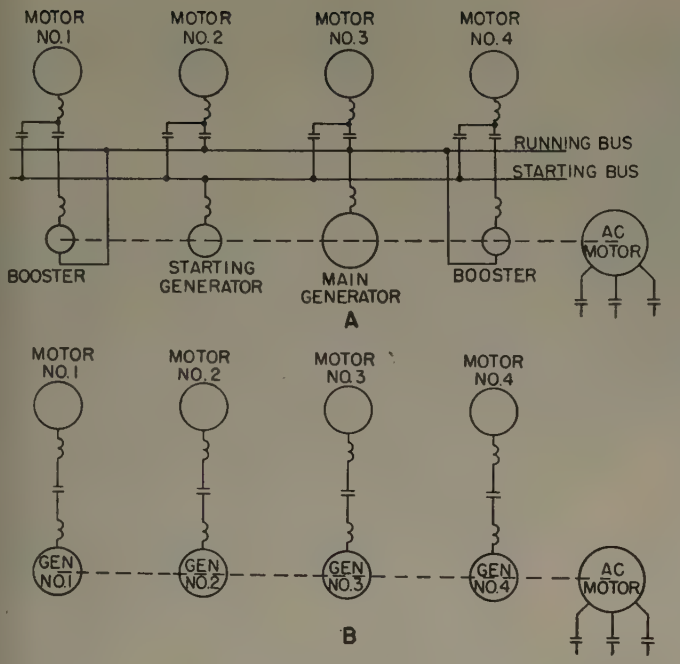


Figure 2. Generator systems

A—Single generator system
B—Individual generator system

Complications arise with such a system, however, when wide speed ranges must be provided, especially under the widely varying load conditions often encountered with multisection machines. Endeavors to match the motor internal voltage drops for proper operation at low speeds results in selection of oversized machines and requires operation at weak field strength with consequent loss of torque. Compensation for differences in the motor internal voltage drops may require the introduction of special high-current low-voltage boosters. All motors may not be started as a group. To permit independent starting of individual motors when the bus voltage is high, the addition of resistance starters or starting generators is necessary. Hence, simplicity is lost and cost climbs with complexity.

The individual generator system eliminates the boosters, starting generators, and oversized machines. Compare, for instance, the 4-motor system at the top of Figure 2 with a similar individual generator system shown at the bottom of Figure 2. A maximum of flexibility is afforded with the individual generator system since any section can be started, stopped, reversed, or jogged without affecting the operation of the other sections. A wide relative speed adjustment is possible with no reduction in the ability of the motor to develop the necessary torque. The use of individual generators produces a similarity between sections which often reduces an otherwise complicated system to merely a group of duplicate systems.

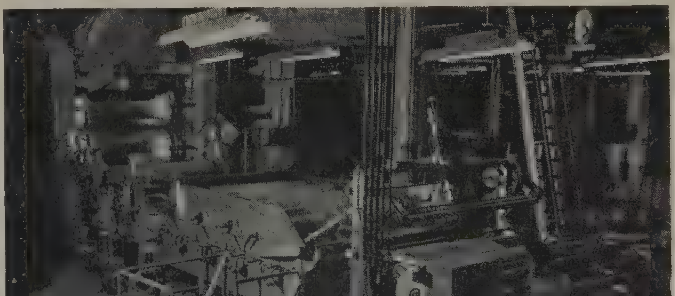
These features of the individual generator system are utilized, for example, in the manufacture of vinyl chloride film, the material used for plastic shower curtains or waterproof baby pants. In this process, vinyl chloride, softened by various solvents, is introduced into a calender, see Figure 3, which is driven by a d-c motor. Moving through the hot rolls of the calender, the material is pressed into a wide sheet of a few mils thickness. It is then passed along over a series of auxiliary drives consisting of a stripper, one or more embossing rolls, several cooling drums, to a winder. A typical flow chart is included in Figure 4.

In the heretofore conventional arrangement, the auxiliary motors would have been grouped together for connection to a common generator. A booster for the winder motor and resistance starters for each motor would have represented the least complicated of workable systems. In most cases, additional boosters were required. Voltage of the auxiliary sections generator was controlled to satisfy the speed regulating requirements of the stripper roll motor. Relative speeds of the other motors were then regulated by strengthening or weakening their shunt fields. Thus the motors were often larger than necessary for the torque required. Even then it was sometimes difficult to get a smooth start in train from standstill. The only way in which a hard-to-start section would hold its place with the others would be to weaken motor shunt field strength. This had the effect of reducing accelerating ability. In extreme cases, motor torque would be destroyed entirely and the motor would not start.

The addition of more boosters tended to correct this situation by limiting the degree of field weakening necessary. Relative speed adjustment was accomplished by a combination of armature voltage and field control. Unfortunately, no reduction in the size of the common generator could accompany the addition of boosters, and generating capacity often considerably exceeded actual requirements.

Up-to-date practice is to eliminate the boosters and resistance starters, and to furnish an individual generator for each section motor as shown in Figure 4. Speed then can be controlled entirely by adjusting the generator voltage. In addition to advantages previously discussed, this arrangement permits easy adaptation of motor speed for use of standard gear reduction ratios. A small motor shunt field adjustment will set the top speed to match gear speed, if within range.

These gains in operating excellence actually have been achieved at less cost, when, as will be discussed later, pack-



Courtesy Adamson United Company

Figure 3. Large calender with auxiliary sections for producing plastic film

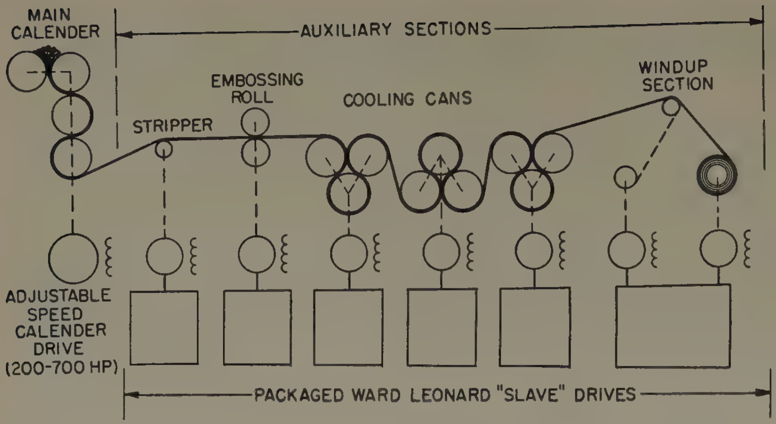

MAIN CALENDER
AUXILIARY SECTIONS
EMBOSSING ROLL
COOLING CANS
WINDUP SECTION
STRIPPER
ADJUSTABLE SPEED CALENDER DRIVE (200-700 HP)
PACKAGED WARD LEONARD "SLAVE" DRIVES

Figure 4. Schematic diagram of plastic film calender train drive

aged drives replaced generators and composite control for all of the follower sections. Acceptance of this arrangement by the plastics industry has been universal, and there are now or soon will be several of these systems operating in the United States and Canada.

By permitting the drive motors to operate always at near full field, a faster speed-regulator transient response is obtained with the individual generator system. This feature and the ability to accelerate evenly high-inertia hard break-away sections have particularly suited individual generator drives to paper machines. A modern mill is seen in Figure 5. In this up-to-date Fourdrinier paper machine, the couch, press drives, dryer sections, calender, and reel each is driven by an individual d-c motor and associated generator.

The 1-line diagram of Figure 6 illustrates the similarity between sections, showing how section is added to section in line-up fashion. Here also is emphasized the unit drive aspect of the individual generator system.

One section of the electric drive system contains all the elements of an independent adjustable-speed d-c drive except for a separate a-c driving motor, its starter, a motor field supply, and a speed-regulator reference voltage. These elements, or their equivalent, have been added in the case of the so-called packaged drives. Later discussion will show how these standardized systems can be grouped to perform successfully on multisection machines.

The decision to employ individual generators is governed principally by the functions the drive motors must perform together and independently. The single generator or rectifier adjustable-speed d-c system is suited to multisection machines when

1. The machine operates over a limited speed range.
2. Proportional acceleration from standstill and deceleration to standstill are not required.
3. The range of stretch and shrink between sections is limited.
4. Loads remain fairly constant and are known.
5. Motors are always started as a group.

Though many applications are characterized by these limits, industrial processes are steadily being added to the field beyond these limits. For these machines, an individual generator system should be used.

PACKAGED ADJUSTABLE-SPEED D-C DRIVES

THE PACKAGED D-C DRIVES which give adjustable speed from a-c power are available to cover a range from fractions of a horsepower to 600 horsepower. There are a number of different types, but the principal systems are electronic, using thyratrons or ignitrons, and Ward Leonard, using motor-generator sets. They are compact equipments which are listed by horsepower, speed, alternating voltage, phase, and frequency, thus freeing those who apply them from the labor of matching kilowatts to horsepower, with unknown efficiency and shunt field information. Generally, the equipment consists of a single enclosed-power-unit package to accompany a motor and control station as a complete drive.

Figure 7 includes a schematic representation of the elec-

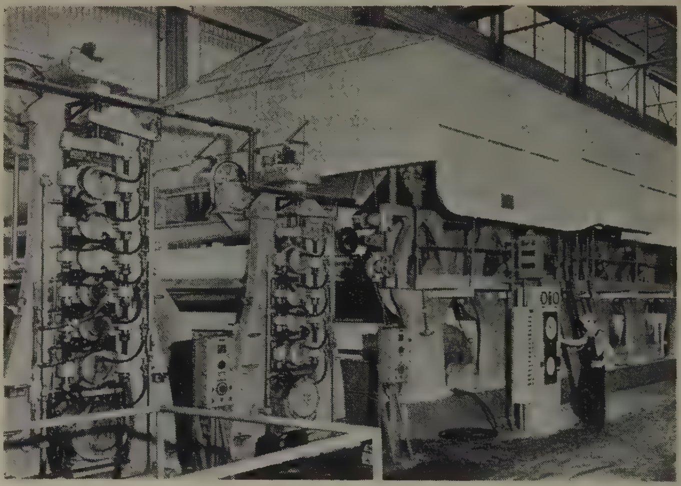


Figure 5. Dry end of paper machine showing dryer section and two calenders

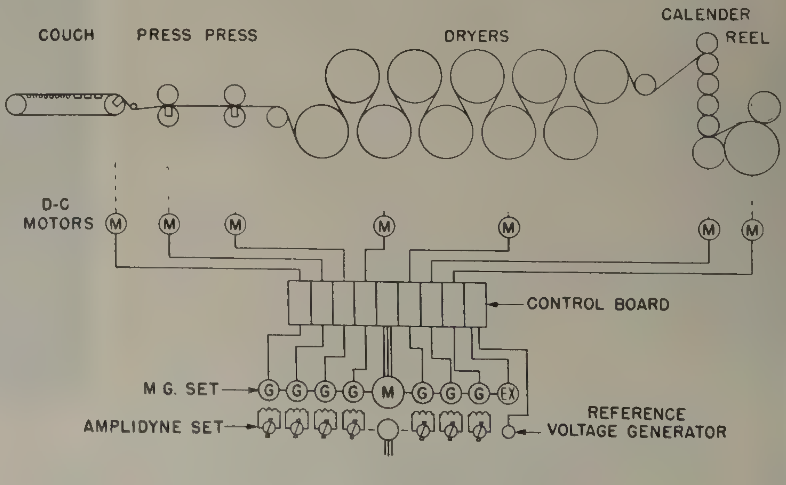


Figure 6. Individual generator system for paper machine drives

tronic type for between 3/4 and 3 horsepower using grid-controlled thyratrons. The system provides both armature and field power for the d-c motor by full-wave rectification of alternating current. An electronic control unit regulates the rectified voltage in response to a d-c reference voltage. A modification can be employed by which speed is regulated as measured by a motor-mounted tachometer. The desired speed, or voltage, may be preset from an operator's control station, or it may be made to follow the voltage of a master tachometer on another machine. Several other standard modifications further broaden its field of application. In the range 5 to 30 horsepower the panels are, of course, larger and employ 1/4-, 3-, or 6-phase rectification.

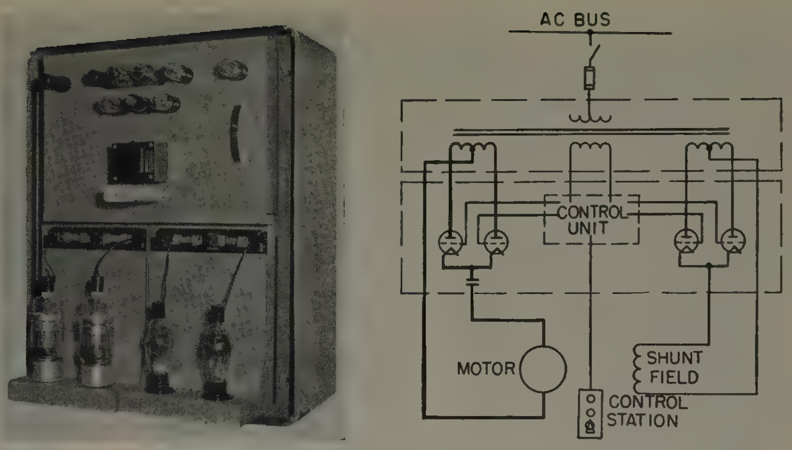


Figure 7. Small electronic motor drives

A—Electronic motor drive typical of sizes 3/4 to 3 horsepower. Anode transformer and fused disconnect switch are separately mounted and are not shown
B—Circuit schematic of small electronic motor drive

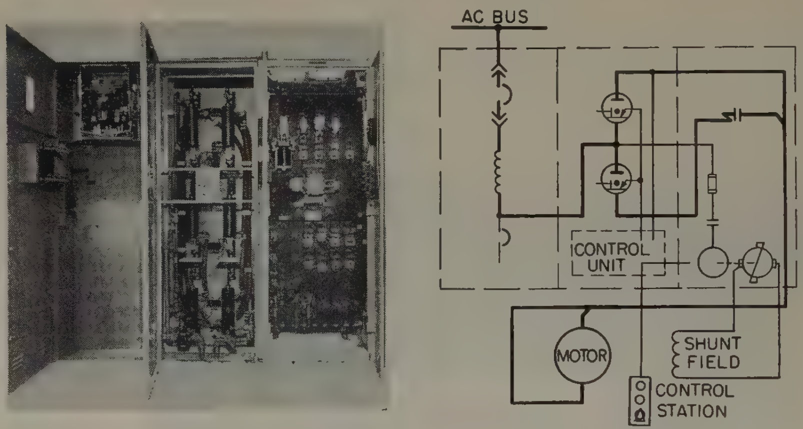


Figure 8. Large electronic motor drives

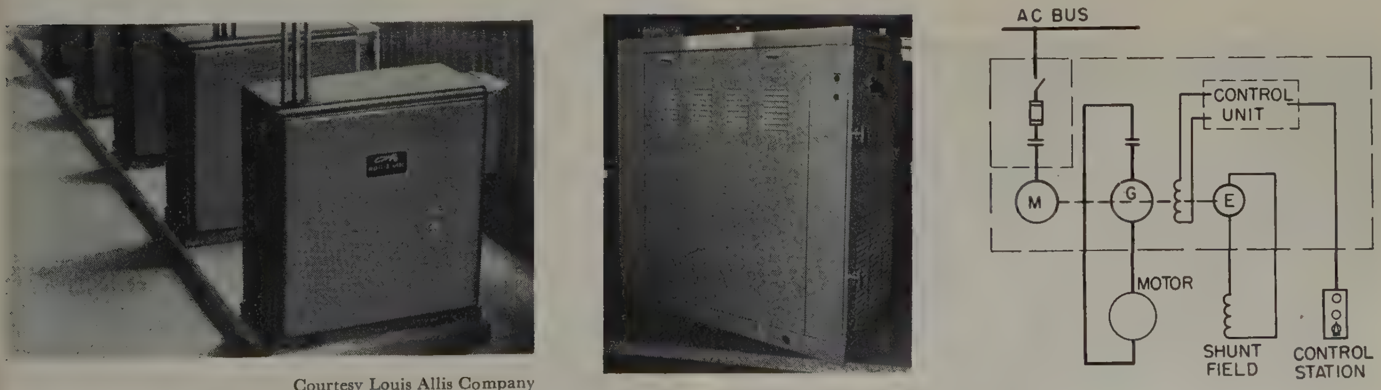
A—Electronic motor drive for sizes 100 to 600 horsepower
B—Circuit schematic of large electronic motor drive

In the range 100 to 600 horsepower, the electronic systems in use today employ ignitrons with a magnetic excitation and control system for regulating motor speed. Actually, operating voltage is regulated, but by a motor internal voltage drop compensation system, motor speed regulation is essentially flat at all operating voltages and loads. This d-c adjustable-speed system includes a motor, a control station, and a power unit package, the latter consisting of an a-c power cubicle, a rectifier cubicle, and a control cubicle as illustrated in Figure 8.

All of the electronic packaged drives give the excellent performance of adjustable-voltage drives in general. However, the differences between the electronic and Ward Leonard types should be understood in making applications to different adjustable-speed machines.

The electronic rectifier cannot accept reverse power like the generator of a Ward Leonard drive, and is at a disadvantage if controlled braking of the motor becomes necessary. Dynamic braking must be employed to get quick stopping. Similarly, reversing is not possible, except by the use of motor armature or field circuit switching.

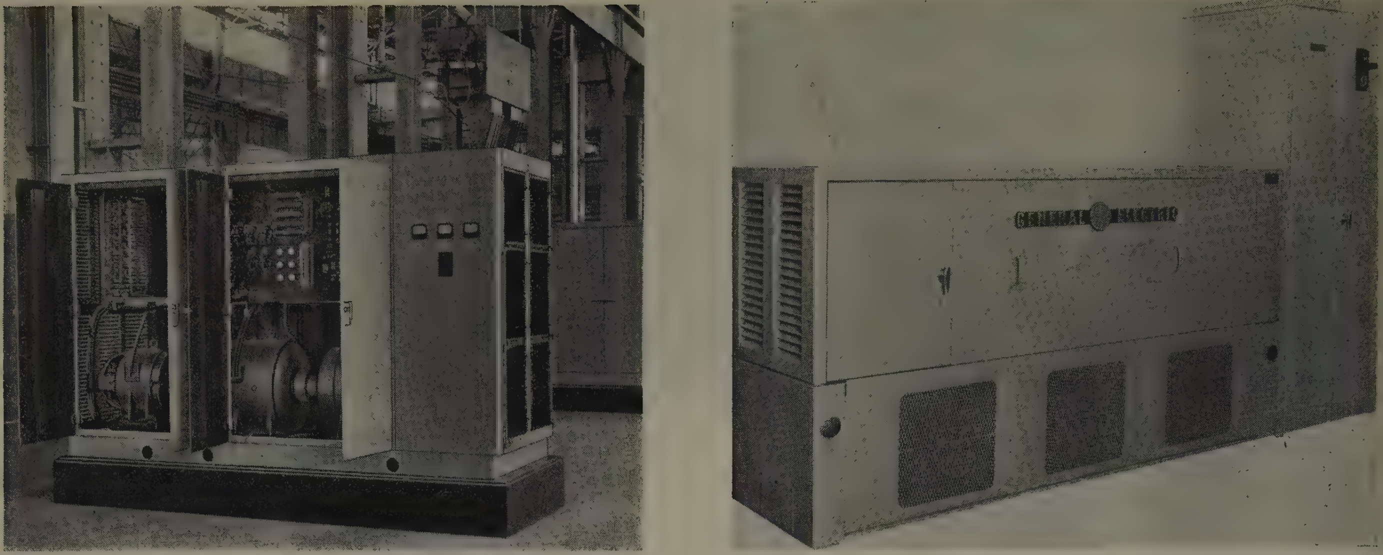
The rectifier has substantially a constant kilovolt-ampere input regardless of output voltage and kilowatts for the same values of direct current. Hence, power factor varies almost directly as percentage of voltage. However, this



Courtesy Louis Allis Company

Figure 9. Small- and medium-sized packaged power units (left to right)

A—Group of packaged power units of the Ward Leonard type. These are typical of the smaller, 5 to 15 horsepower, ratings. B—Packaged power unit for 30-horsepower drive. C—Circuit schematic of packaged Ward Leonard drive for small and medium sizes



Courtesy Reliance Electric and Engineering Company

Figure 10. Large packaged power units

A—Packaged power unit for 200-horsepower drive. Motor-generator set and control are in a single enclosure. B—Large power unit with control in separate cubicle

Figure 11. The line-up of packaged adjustable-speed-drive power units for the auxiliary sections of the plastic film calender train

disadvantage does not become important except at higher horsepowers and when running speed range is wide. Reduction in power factor can be minimized by obtaining part or all of this speed range by motor field control. The large rectifier drives have substantially higher efficiencies than Ward Leonard drives, and standby losses are considerably less.

The electronic systems have an installation advantage over their Ward Leonard counterpart by being lighter in weight and requiring less floor space. The smaller size electronic units even may be wall-mounted. On some print-reproducing machines and machine tools, for example, they are built right into the machines. Some of the Ward Leonard power units require a nondeflecting base, whereas rectifier units up to the largest are self-supporting.

The Ward Leonard packaged drive consists typically of an induction motor-generator set, control, and field supply

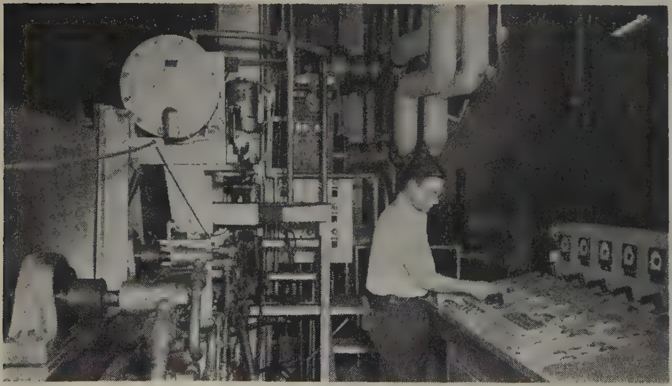


Figure 12. The plastic film calender train and operator's control desk

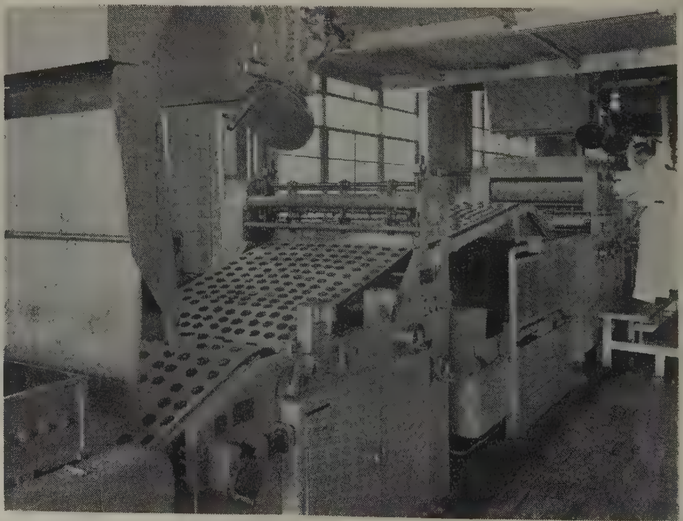


Figure 13. A multisection machine for automatic baking of cookies

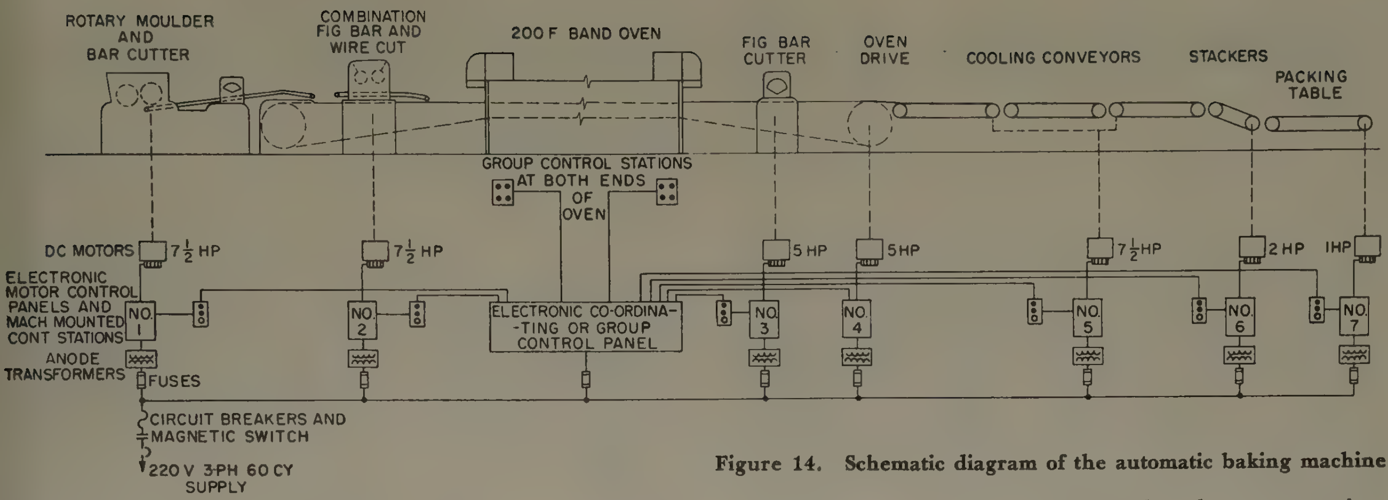

ROTARY MOULDER AND BAR CUTTER
COMBINATION FIG BAR AND WIRE CUT
200 F BAND OVEN
FIG BAR CUTTER
OVEN DRIVE
COOLING CONVEYORS
STACKERS
PACKING TABLE
GROUP CONTROL STATIONS AT BOTH ENDS OF OVEN
DC MOTORS
7½ HP
7½ HP
5 HP
5HP
7½HP
2 HP
1HP
ELECTRONIC MOTOR CONTROL PANELS AND MACH MOUNTED CONT STATIONS
NO. 1
NO. 2
ELECTRONIC CO-ORDINATING OR GROUP CONTROL PANEL
NO. 3
NO. 4
NO. 5
NO. 6
NO. 7
ANODE TRANSFORMERS
FUSES
CIRCUIT BREAKERS AND MAGNETIC SWITCH
220 V 3-PH 60 CY SUPPLY

Figure 14. Schematic diagram of the automatic baking machine

in a compact enclosure as shown in Figure 9, *A* and *B*. For ratings 75–200 horsepower, two arrangements are offered as seen in Figure 10, *A* and *B*, the former in a single large cabinet is more common. One drive has a separate control enclosure for mounting either integrally with the motor-generator set enclosure, see in Figure 10*B*, or in a line-up of other controllers with similar dimensions.

Unlike the electronic drives, the Ward Leonard system readily permits regeneration by the d-c motor, and thus can be applied where controlled braking is required as on unwind sections; also, reversing is achieved easily by reversing the generator field and hence armature voltage.

The motor-generator set includes a shaft fan, and the enclosure is constructed so that air is filtered before entering the machines. The air discharge maintains a slight positive pressure in the enclosure. Control devices remain cleaner in dusty locations with this feature.

The Ward Leonard system is available without regulating attachments, in which case it becomes very simple electrically. A regulating control unit is a basic part of the electronic systems so that they are fundamentally more complex. However, modifications can be made to the Ward Leonard system to give automatic regulation of speed, voltage, current, or position. The functional flexibility of this system, which is inherent in the design approach, is one of its greatest advantages.

As stated before, the use of individual generators for the sections of multisection machines creates a unit drive aspect about each section to which packaged drives are readily adapted. As master* or follower section drives, about all that must be done to employ packaged equipments is to provide a small co-ordinating control. In the Ward Leonard type of packaged drive, when follower sections are required to track a master section speed, a "slave unit"** type of regulator can be provided. This can be a standard modification and consists of mounting a tachometer on the follower motor and adding the regulator to the power unit enclosure. With a separate co-ordinating control or by adding a relay to each section control, a group of packaged drives can be arranged to start and stop as a group, automatically tracking in speed with individual adjustment over speed ratio. Sections can be operated independently regardless of whether the machine is shut down or running.

Figure 11 pictures the line-up of packaged drive power units for the auxiliary sections of the plastic film calender drive shown in Figure 3. These are mounted on a balcony near the calender. In this case, the central co-ordinating control for these six units is mounted inside of the main operator's control desk, Figure 12, where space is available and where interconnection is made easy.

In the automatic baking of cookies or biscuits, see Figure 13, a line-up of small packaged electronic drives has been used with success. The schematic flow and 1-line diagram for this machine, Figure 14, shows a central co-ordinating panel used to get the desired group performance.

When a multisection machine requires an individual generator to a section, packaged drives should be considered. Few machines need horsepower sizes exceeding the 1–200 horsepower range sizes for which both electronic and Ward Leonard types are available. Packaged drives offer many advantages: low cost—as they are suited to the motor's horsepower rating and produced in quantity they greatly undersell equivalent conventional equipment. Ordering a complete system rated by a-c power supply and mechanical output is simple; standard modifications cover many special applications. The enclosed Ward Leonard type or static electronic type may eliminate need for a separate control and motor-generator room. These drives often can be installed without additional construction. Even in special rooms they use as little as one-half the usual floor space. Nondeflecting foundations are seldom required. Initial startup troubles are minimized as equipments are factory assembled, interconnected, and tested. Being system-engineered and produced in quantity, less engineering time is required per application. Only co-ordination needs extra attention, and this is made easy by good initial design. Individual units can be installed and operated singly, and if process-engineering requirements change, a section can be removed freeing a complete drive system for use elsewhere.

Packaged drives fit the individual generator system very well and lend themselves to easy co-ordination with each other or with a large master drive. In view of the flexibility which they bring to such a system, and their lower cost, consideration should be given to their use in the sizes for which they are available.

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* A "master" drive is one which starts or stops a machine or process, sets the speed of the machine, and controls the rate of acceleration and deceleration.

** A "slave" drive follows its master.

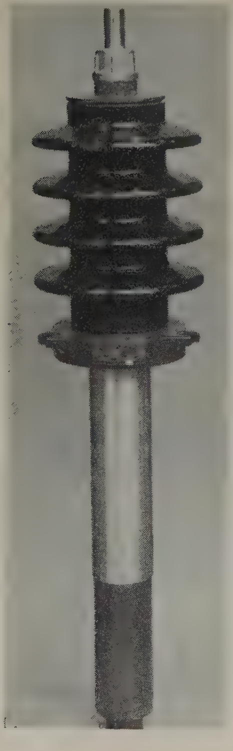
Apparatus Bushing With Improved Characteristics

R. N. ANDERSON   D. L. JOHNSTON
ASSOCIATE MEMBER AIEE

THE OBJECTIVE OF combining improved performance with saving in materials has been accomplished in the redesign of a line of liquid-filled bushings in ratings 15 kv through 69 kv. In this redesign, the mechanical and electrical reliability of the bushings in service has been improved and field servicing and repairs have been facilitated. Simultaneously, the design has been simplified to reduce the size of some parts and eliminate others.

The new design is center clamped. This means that the porcelain is placed in compression, under which stress porcelain has the greatest strength. The center-clamping force is exerted by threading the cap down against a Belleville washer. This Belleville washer serves as the flexible member between the center conductor and the bushing shell and also as the top-end seal of the bushing chamber. Since the mounting flange is not connected directly to the porcelain on the new design, bolting torque applied in mounting the bushing to the apparatus cannot damage the porcelain shell.

The support of the new design is of high-strength heat-treated aluminum. The ground sleeve for the new bushing is aluminum tubing. Close tolerances in ground-sleeve diameters along with accurate machining of resin-impregnated insulation and a press and shrink fit between these parts, results in a strong and permanent bond between the ground sleeve and the insulation. The support of the new design also is assembled to the insulation and to the ground sleeve with a press and shrink fit resulting in a strong mechanical joint.



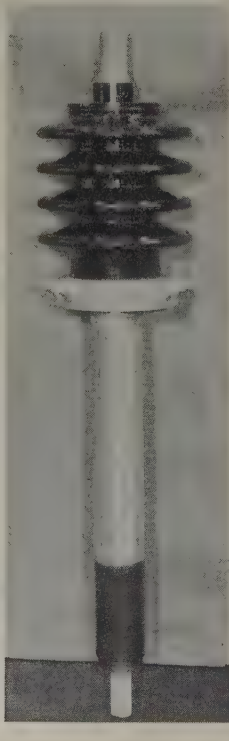


Figure 1 (left). Center-clamped bushing for transformer rated 34.5 kv

Figure 2 (right). Center-clamped bushing for oil circuit breakers rated 25 kv

Should a porcelain shell be broken accidentally, field repairs can be made on the new design with little difficulty because the mounting flange can remain bolted in place during removal of the old porcelain and replacement with a new one.

Momentary or maintained imposition of an excessive transverse load on the top end of the porcelain is of serious consequence because in many bushing designs it results in a broken porcelain. The new design is stronger against the effects of transverse loading than the old design and the results of an excessive force are less serious.

During circuit-breaker interrupting tests, which are necessary to prove the adequacy of any new design, axial and transverse loads are imposed on the bottom end of the bushing. Each rating of the new design has taken these tests without incident.

A special coating is added to the bottom insulation of the new circuit-breaker bushing to inhibit the deposition of carbon particles on this surface.[1] The old design required a bottom porcelain and other bracing when applied on oil circuit breakers. The new design, due to its greater mechanical strength, can operate in a circuit breaker without a bottom porcelain, which facilitates inspection and cleaning of the bottom end of the bushing.

A new line of center-clamped bushings for ratings of 15 kv through 69 kv has been developed. The new design for transformers is shown in Figure 1 and the new design for oil circuit breakers in Figure 2.

The new design has been thoroughly tested and complies with all requirements of AIEE and National Electrical Manufacturers Association Standards. It has been proved equal electrically and superior mechanically to the superseded design.

Principal features of the new design are: simplified design, shorter manufacturing cycle, broken porcelain can be replaced easily in the field without removing bushing from apparatus, lighter weight facilitates handling in the field, rugged construction attained by placing porcelain in compression, bottom porcelain not required for circuit-breaker applications, and use of less critical material.

The new design incorporates the time-tested good features of the old design, and should establish an even more enviable record of service to users.

REFERENCE

1. Operation of Bushings in Carbonized Oil, **Lynn Wetherill, W. R. Wilson.** AIEE *Transactions*, volume 70, part II, 1951, pages 1398–1407.

Digest of paper **52-195,** "New Apparatus Bushing With Improved Characteristics," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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A New General-Purpose Relay for Telephone Switching Systems

A. C. KELLER

This new general-purpose electromagnetic relay, called the AF type, is a wire spring relay. With variations providing slow release or marginal characteristics, it is known as the AG and AJ relay respectively. It provides improved performance at lower cost.

THE GENERAL-purpose relay is one of the most important components of telephone switching systems. Since several million are produced annually, low manufacturing cost is extremely desirable. Also of prime importance are low operating and maintenance costs. A general-purpose relay for telephone switching systems must meet a large number of diverse requirements. It must be capable of being assembled with any one of a variety of magnet coils having a wide range of resistance values and must operate contacts which vary from one pair to as many as 14 or more. The basic relay design also must be capable of providing such features as fast operation and release, slow release, high sensitivity, heavy duty, and marginal operation. These functions are performed satisfactorily in present crossbar switching systems by *U*-, *UA*-, *UB*-, and *Y*-type relays. However, with an objective of a 40-year life for new switching systems and a trend toward unattended operation of switching offices, it is important to attain the best in the performance and reliability of relays.

REQUIREMENTS AND OBJECTIVES

THE REQUIREMENTS FOR a new general-purpose relay were initially broadly stated to be performance and maintenance at least equal to the *U*- and *Y*-type relays but with substantially lower manufacturing costs. As development proceeded, it became possible to design the new relay to operate and release faster or to use less electric power, to operate more often before appreciable wear occurred, and so forth. The *AF* relay's improved performance characteristics are of equal economic importance to those associated with lower manufacturing cost.

The broad requirements were reduced to the following design objectives: (1) lower cost—50 per cent of *U*-type relay; (2) reduced operating electric power; (3) faster operate and release times; (4) long life—one billion operations; and (5) improved contact performance.

DESIGN POSSIBILITIES

THE STUDIES OF new relay design possibilities started with a review of the *U*-type relay experience. In general, these studies indicated that about half of the manufacturing cost of *U*-type relays came from assembly and adjusting operations. Accordingly, these operations required major revision for a substantial cost reduction of the relay. It became evident that the development of new manufacturing methods as well as new designs were essential in reaching the ambitious objectives.

Many new forms of relay designs were considered and studied including such types as miniature, magnetic contact, and piezoelectric. As a result, one general form, first proposed by H. C. Harrison, gave the most promise of meeting the manifold requirements: the wire spring type characterized by the wire spring subassemblies with code card operation of pretensioned, low stiffness springs.

PRINCIPLE OF CONTACT OPERATION

THE AF RELAY USES the so-called "single card system" for actuating the contacts. A typical *AF*-type relay is shown in Figure 1, and its parts are shown in Figure 2. The method for obtaining individual make- and break-contacts with this system and the means for obtaining transfer contacts, in which both make and break twin contacts are associated with a common stationary contact, are shown in Figure 3. The following principles have been incorporated in this particular method of actuating the contacts:

1. In general, three basic wire spring assemblies are required. Two of these carry movable twin wires for make- and break-contacts. These assemblies are mounted on either side of the stationary wire assembly.

2. Moving twin contacts on separate twin wires are used with every stationary contact.

3. Each group of twin wires is tensioned toward the stationary wires by means of large predeflections before assembly. Good control of the contact force is assured without need for hand adjustment because small variations

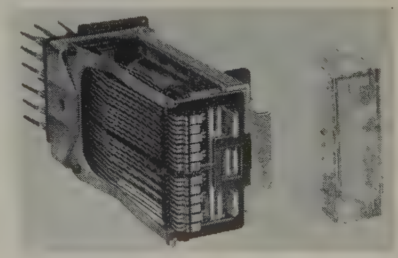

Figure 1. AF-type relay, with contact cover detached

Condensed text of paper **52-304**, "A New General-Purpose Relay for Telephone Switching Systems," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, New Orleans, La., October 13–17, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952. The complete paper appears in *Communication and Electronics*, November 1952.

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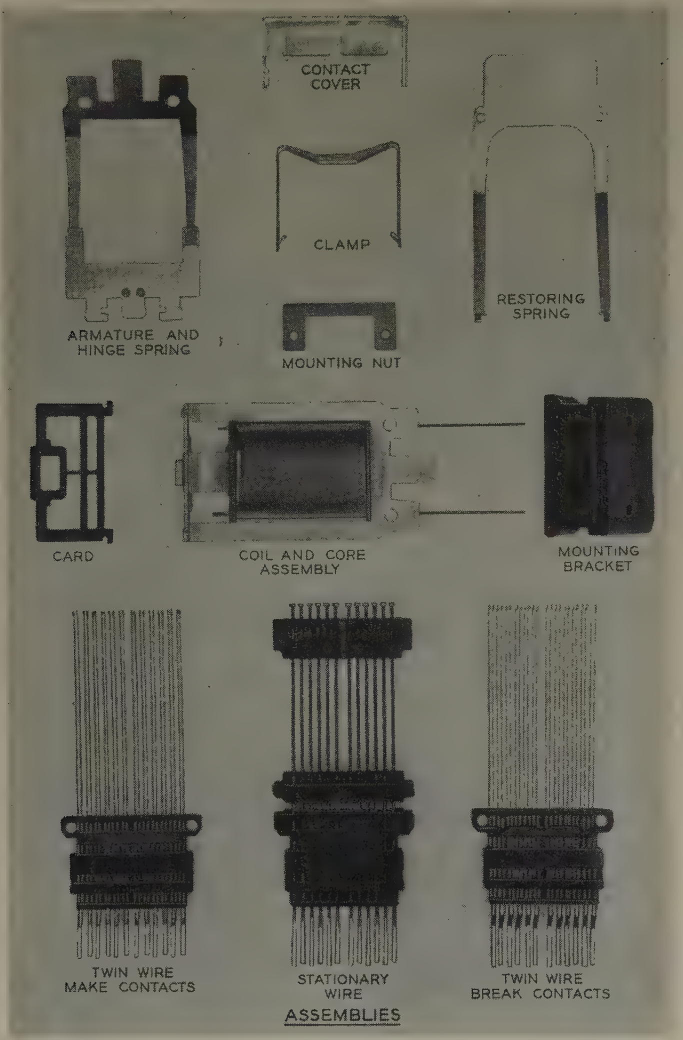

Figure 2. Parts of the wire spring relay

in deflection of the low stiffness springs do not result in appreciable changes in force.

4. The twin wires are actuated by a single card. Since the tension in the twin wires is always in a direction to hold the contacts closed, the card serves to hold the make-contacts open when the relay is unoperated, and the break-contacts open when the relay is energized.

5. The card is supported by the armature on one side and a restoring spring on the other. This spring supplies the force to hold the armature against the backstop and to hold make-contacts open when the relay is unoperated, while the armature supplies the force to hold the break-contacts open when the relay is operated.

6. The twin contacts are held in good registration with their associated stationary contacts by molded guide slots in the stationary plastic member just behind the card.

As the armature moves toward the core, the particular point in its travel at which make-contacts close and break-contacts open depends upon the dimensions of the card. By proper selection of these dimensions, any contact can be controlled to operate early or late in the travel as desired. By this means, several sequential contact arrangements may be obtained. For example, if the break-contact in Figure 3 opens earlier in the travel than its associated make-contact closes, the result is called an "early break-make" transfer. Similarly, an "early make-break" transfer, called a "continuity," is one in which the make-contact closes before the break-contact opens. If both contacts operate simultaneously, the result is a "nonsequence" transfer. Thus it is evident that the card surfaces which engage the twin wires must be in different positions for early contacts as compared with late contacts, as shown in Figure 4.

ARMATURE SYSTEM AND MAGNETIC CIRCUIT

THE ARMATURE SYSTEM and the associated magnetic circuits constitute the basic motor element of an electromagnetic relay. The size of the motor element is determined, in part, by the work it must do and here a basic factor is the contact force. On the basis of analytical as well as experimental studies, it was decided to use a contact force of about 6 grams per single contact, that is, about 12 grams for the combined force of the twin contacts. Other important factors which react on the design of the magnet include speed required, winding space, heating, and sensitivity.

The armature is a flat member of *U* shape which provides desirably large pole-face areas. The core is a simple 1-piece *E*-shape section of sufficient thickness of one per cent silicon iron to produce the magnetic flux needed to meet the force and speed requirements and to provide the main member to which all other parts are assembled. The 1-piece construction avoids welded or butt joints common to many magnets. These joints are responsible for added reluctance and hence decrease the magnet sensitivity and require added electric power to operate a given load. The relatively wide spacing of the legs increases leakage reluctance and, in turn, increases the useful magnetic flux.

After a cellulose-acetate-filled coil has been assembled to the middle leg of the core, a core plate, see Figure 5, is forced over the ends of the *E*-shaped core to hold the three legs in good alignment for proper mating with the armature. The core plate also provides the backstop for the armature and serves as a means of gang adjustment of the contacts.

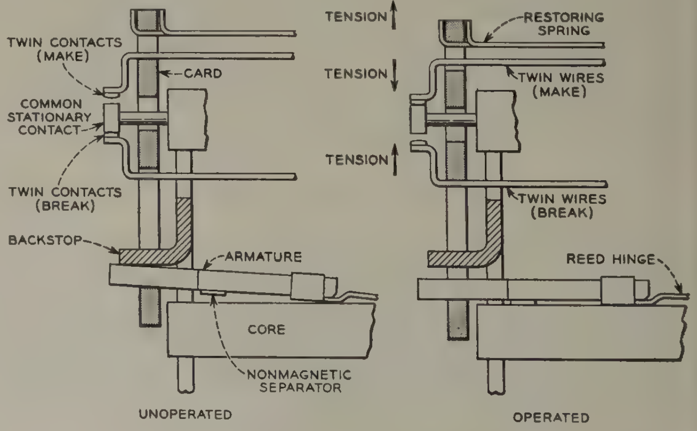

Figure 3. Principle of contact operation

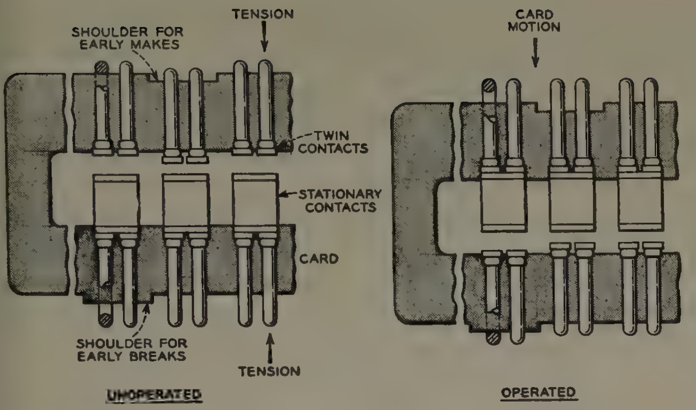

Figure 4. Early break-make, early make-break, and nonsequence transfer contacts, showing how early contacts are obtained by means of shoulders on the actuating card

The armature is spring supported in a very definite manner to produce a minimum of rebound when it is released from its operated position. The conditions for reducing armature rebound make it necessary to proportion the forces at the front and rear of the armature properly. The magnitude and the ratio of these forces are a function of the mass distribution of the armature.

For comparison with the *U*-type relay, the following typical constants of the magnet are of interest. The closed gap reluctance, $\mathcal{R}_o$, is the reluctance of the magnetic circuit, excluding leakage paths, with the armature operated and with the iron near maximum permeability. The coil constant, G, is the ratio of the square of the number of turns to the resistance for a full sized coil. The sensitivity, S, is a measure of the ultimate work capacity of the magnet as related to the power input and has been defined as $S=5\pi G/\mathcal{R}_o$ ergs per watt.

	AF Relay	U Relay
Closed gap reluctance $\mathcal{R}_o$, cm^{-1}	0.028	0.065
Coil constant G, kilomhos	160	160
Sensitivity S, ergs per watt	90,000	39,000

MOLDED WIRE SPRING SUBASSEMBLIES

One of the major features of the new relay is the use of molded wire spring subassemblies and as a result the number of parts handled in the assembly of the contact spring members is greatly reduced. Three wire spring combs are needed for any contact combination which includes both make- and break-contacts up to 12 makes and 12 breaks. Four wire spring combs are needed for a relay having 24 make-contacts.

Two problems had to be solved in providing molded wire spring combs, namely, wire straightening and molding of a multiplicity of wires. Wire is straightened by rotating cam and die members around the unstraightened wire which cause alternating flexing of the wire. For best results, it was found important to shape the cams properly and to push, rather than to pull, the wire through the rotating cams. Figure 6 shows continuous ladders of molded wire spring sections before cutting to length.

CONTACTS AND CONTACT WELDING

Since the primary purpose of the relay is to open and close electric circuits through the contacts, there has been a special effort to make these contacts as reliable as possible. Accordingly, palladium is used for all contact surfaces. The use of this precious metal substantially eliminates opens due to corrosion. It not only has proved able to provide outstanding reliability, but, in addition, the studies which have been made indicate that its use results in the best economic balance between manufacturing and service costs because of the reduction in maintenance requirements.

Open circuits due to particles of dirt between the contact surfaces are largely eliminated by the use of a contact cover, complete independence of the twin contacts, and the dynamic characteristics of the wire springs. However, to reduce the incidence of dirt troubles further, the surfaces of the twin contacts are coined to a cylindrical shape.

The twin contacts are produced by spot welding precious metal contact tapes to the tips of the twin wires. This process, however, did not appear best for welding the stationary contacts to the ends of the wires because of the need to grip the wires with heavy welding electrodes in the limited space directly behind the contacts. Accordingly, a type of welding known as "percussive welding" was developed, which permits one of the electrodes to be placed near the wiring end of the wire springs without developing excessive heat in the wires and which also permits the accurate positioning needed for the contacts in order to control the point of contact closure on the assembled relay.

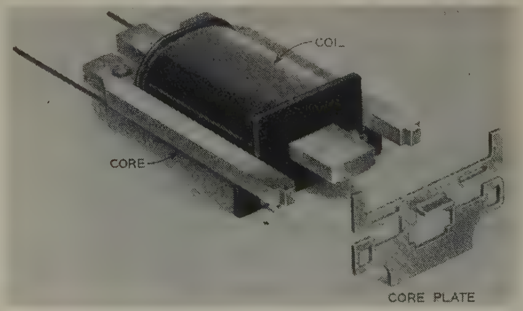

Figure 5. Legs of the core are held in alignment by the core plate, which is forced over the ends after the coil is assembled

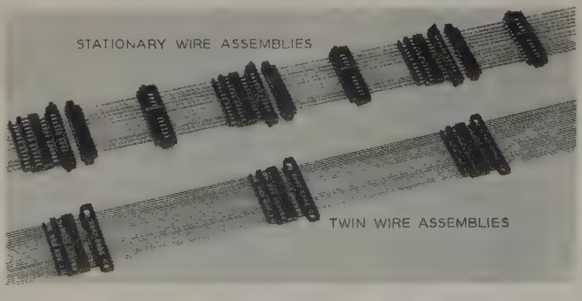

Figure 6. Molded stationary and twin wire assemblies, before cutting to length

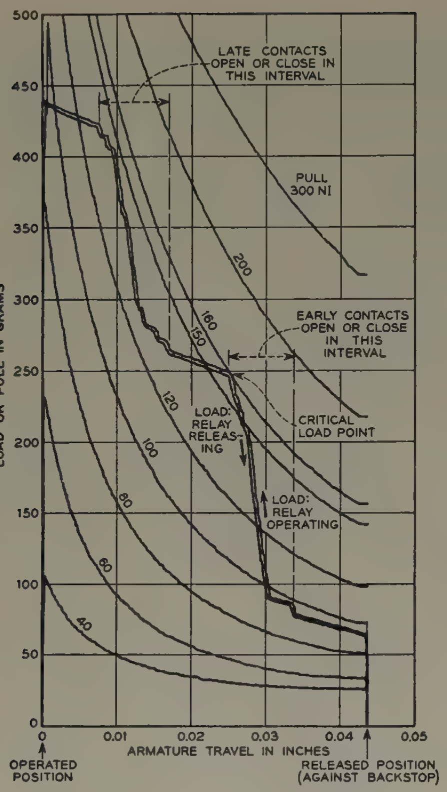

Figure 7. Typical load and pull characteristics of a wire spring relay with 12 early break-make transfer contacts

STANDARDIZED ASSEMBLY OF CODED PARTS

Since assembly was one of the most promising fields for reducing costs, special effort was made to reduce the assembly cost of the *AF* relay. Some of the major design features which contribute to it are

1. The continuous molding and fabricating processes for the wire spring subassemblies, which avoid all individual handling of wires and contacts.
2. Clamping the relay pile-ups by means of a simple spring clamp instead of the more conventional method using screws.
3. A single, easily mounted, operating card.

Less obvious, but equally important, is the basic philosophy whereby a large variety of different relay codes are obtained by assembling parts which for assembly purposes are essentially identical for each code. At the present time six different card varieties, 50 twin-wire assemblies, and 75 stationary-wire assemblies have been standardized. However, with these it is possible to obtain more than 300 different contact combinations. Yet, with surprisingly few exceptions, each relay code can be assembled from the same number of parts put together in the same manner.

RELAY ADJUSTMENT

Since adjustment expense accounts for a considerable part of the manufacturing costs of older type relays, special efforts were made in the design of the *AF* relay to reduce the need for adjustment. As a result several types of adjustment have been eliminated completely and the remaining adjustments have been simplified. All individual contact adjustment has been eliminated and only two types of factory adjustments are made with the *AF* relay. These include adjustment of the restoring spring to control armature back tension, and a gang adjustment of the stationary contacts to control the points in the armature travel at which the contacts operate. Even these adjustments are needed for only a fraction of the relays as close control of the tolerances in manufacture often causes the back tension and contact operate points to fall within acceptable limits as the relays are assembled.

The gang adjustment of the stationary contacts is made by bending the arms of the core plate, thereby changing the position of the front molded section of the stationary-wire assembly which rests on the ends of the arms.

Types of factory adjustment which are common on other relays, but which have been eliminated on the *AF* relay, include adjustments for contact force, individual adjustment of contacts for contact operate point, and adjustment for armature travel. Contact force is controlled by means of the large predeflections of the twin wires. Individual contact adjustment is eliminated by close control of tolerances combined with the single-card method of actuation, and by the simpler gang adjustment used when necessary. Adjustment for armature travel is eliminated by the use of close tolerances on the controlling dimensions of the parts.

RELAY PERFORMANCE

The broad objective in the design of the *AF* relay has been to reduce the annual charges for its use in the telephone system. Part of this reduction comes from lower manufacturing costs, the remainder from savings associated with the improved performance characteristics. These include long life with relatively low maintenance expense, reduced power consumption, and increased speed which reduces the number of units of certain types of equipment, such as markers, needed for telephone central offices. The principal characteristics of the new relay are

Load and Pull Characteristics. Figure 7 shows typical load and pull curves for a wire spring relay with 12 early break-make transfer contacts. The abscissa shows the motion of the armature as it travels from the unoperated position to the operated position, and back again. The

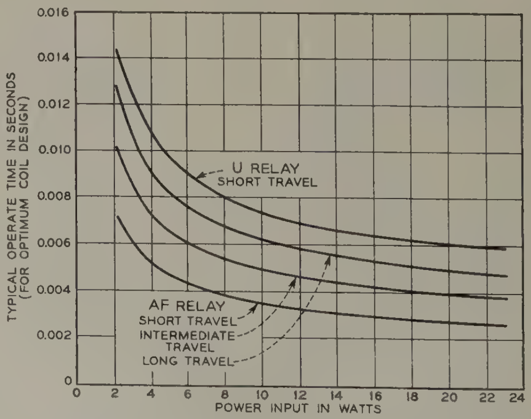

Figure 8. Typical operate times of speed relays with optimum coil designs for high-speed operation

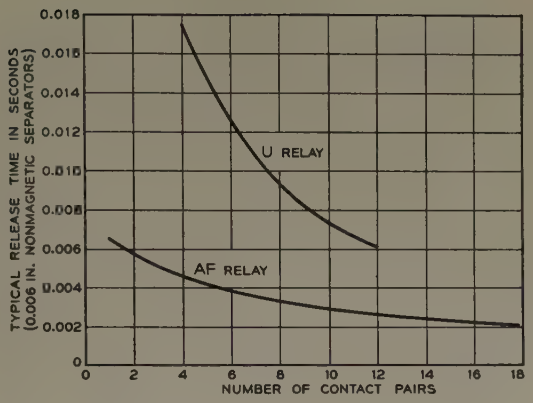

Figure 9. Typical release times of AF and U relays

ordinate shows the spring load, which opposes the armature motion toward the core, and the magnetic pull acting on the armature for various numbers of ampere-turns in the winding.

As the armature moves toward the core, the spring load increases along the upper of the two nearly parallel load curves until it reaches a final value of about 440 grams in the operated position. As the armature is allowed to return to its original position, a second curve, just below the original curve, is obtained. The area between these two curves is a measure of the energy loss due to mechanical hysteresis, or friction, in the relay. As can be seen from the curves, the friction in the new relay is very low and is a small fraction of the spring load at all values of armature travel.

Speed of Operation and Release. Typical operate and release times of the *AF* relay are shown in Figures 8 and 9. Figure 8 shows the operate times for "speed relays" in which the speed is limited primarily by the time needed to accelerate the mass of the moving system, and is not affected appreciably by the spring loads. For comparison, a short travel *U* relay is also shown. This relay requires about twice the time to operate as the corresponding *AF* relay.

Typical release times for the *AF* and *U* relays are shown in Figure 9, plotted as a function of the number of contact pairs. The improvement is greater than two to one, due principally to the lighter moving parts of the *AF* relay and lower eddy current effects of the rectangular silicon iron core.

Contact Performance. The principal characteristics which must be considered in evaluating contact performance include chatter, erosion or wear, susceptibility to open contacts and locking, and changes in these characteristics with wear of the relays. All these features are improved on the *AF* relay as compared with the *U* type.

Figure 10 shows typical chatter on closure of make- and break-contacts on *U* and *AF* relays built for moderate and fast operation. The reduction in chatter has direct circuit advantages in reducing the possibility of false operation of associated high-speed equipment and also indirect advantages in prolonging the life of the contacts. The improvement is due largely to the type of card operation of the completely independent, low-mass twin wires and also to the low mass of the moving system which excites less vibration of the relay structure as a whole.

Electrical erosion of the contacts is reduced on the *AF* relay because of less chatter and the lower energy levels controlled by the contacts, where these are used to operate other *AF* relays.

Contact locking is substantially eliminated on the *AF* relay because of the card operation, where the static and dynamic forces associated with the card and armature are available to break loose any incipient lock. Open contacts are reduced by (1) protecting the contacts from dust with a small cover, (2) rounding the twin contact surfaces to reduce the effective areas on which particles must lodge to cause opens and to increase the pressure on the areas, (3) the use of palladium contacts, (4) the dynamic characteristics of the wire springs, and (5) the use of twin contacts on completely independent twin wires.

The improvements in contact chatter and open contacts become even more evident during the life of the relay. The contact forces on *U* relays diminish rapidly with wear of the contacts resulting in increased chatter, more frequent opens, and the need for earlier readjustment. Card operation of wire springs with large predeflections, however, assures substantially constant forces, thereby maintaining the initial chatterfree performance and fewer open contacts.

Life. Tests of relays with contacts protected electrically with resistance-capacitor networks indicate that the standard *AF* relays with winding resistances of 700 ohms or greater will have a life in the order of 250–500 million operations before readjustment becomes necessary. With readjustment, of course, these figures can be increased several times. Where longer life is essential, special features are used to increase the life. With these features a life of a billion operations before readjustment is expected for

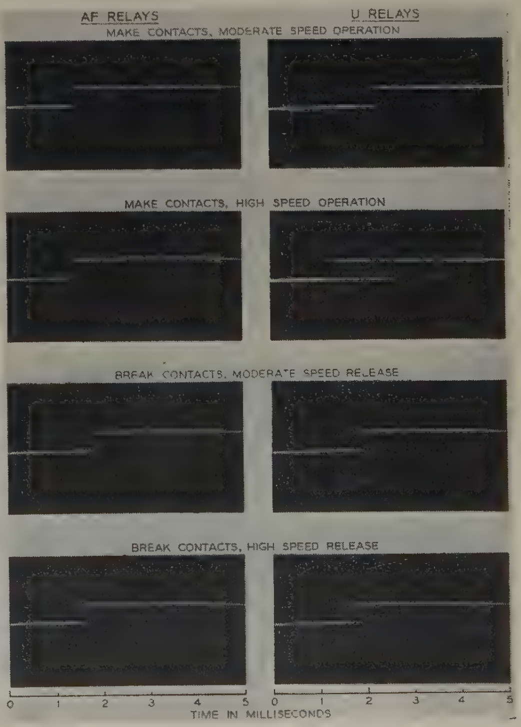

Figure 10. Typical chatter on closure of contacts

some relays and, with readjustment, all relays equipped with the special features for long life should be capable of a billion operations.

The special features for long life include vibration dampers attached to the twin wires and the stationary wire assembly, wear-resistant nickel and chromium plate on the armature, core, and core plate, and a long-wearing alloy for the nonmagnetic separators welded to the armature.

Early designs of relays indicated that wear between the twin wires and the card was excessive and that changes in materials would not produce the improvement needed for very long life, particularly with high-speed relays. A fundamental study of the conditions which cause wear was made and it was found that reduction of the sliding motion between the wires and card to 0.001 inch or less was necessary to substantially eliminate such wear. The *AF* relay meets this requirement.

Magnetic interference between *AF* relays is substantially eliminated. This is largely because of the low reluctance of the magnetic circuit resulting from the 1-piece core and the large pole-face areas between the core and armature. The improvement of *AF* relays with respect to the *U* type is of the order of ten times for most of the range, with the effects of the adjacent relays being well under ten per cent even for extreme conditions. This is small enough so that no shields or precautions with respect to spacing are required.

AG- AND AJ-TYPE RELAYS

These relays include modifications of the basic *AF* design to provide slow release, sensitive, marginal, and other additional characteristics. The additional parts most often used in the *AG* and *AJ* relays are shown in Figure 11. Both relays use thicker armatures with longer side legs than the *AF* relay, and the armature of the *AG* relay has a spherical embossing instead of nonmagnetic separators. This reduces the magnetic circuit reluctance of the *AG* relay when it is in the operated position. In addition, for longer release times, a metal sleeve is assembled over the middle leg of the core, inside the coil. Induced eddy currents in this sleeve oppose rapid changes of flux through the core.

The use of heavy embossed armature and a sleeve are sufficient to make the relay slow to release. When the current in the winding of such a relay is interrupted, the flux decays slowly due to the circulating currents in the sleeve. Also, the low magnetic reluctance increases the time for the flux decay by permitting relatively high flux values to be maintained by smaller circulating currents.

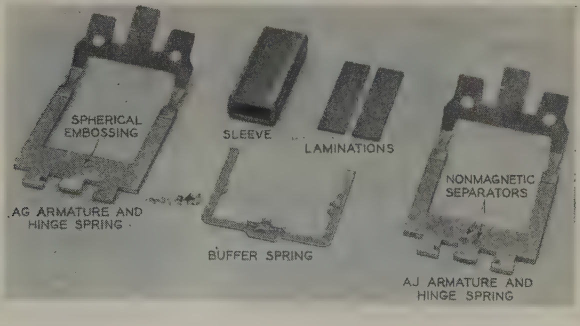

Figure 11. Additional parts for AG and AJ relays

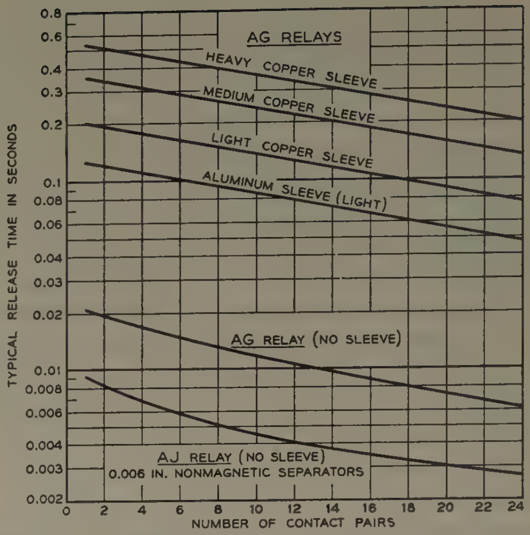

Figure 12. Typical release times of AG and AJ relays

Figure 12 shows typical release times plotted as a function of the contact load for *AG* relays with and without sleeves. The heavier sleeves produce longer release times, which are also greater for relays with fewer contacts. For comparison, release times are also shown for the *AJ* relay, which has a magnetic structure similar to the *AG* but with nonmagnetic separators in place of the spherical embossing on the armature. Under limiting conditions the *AJ* relay will operate on as little as 0.025 watt.

Features which may be used to extend the use of the *AJ* relay for special marginal applications include armatures with various thicknesses of nonmagnetic separators, wire spring assemblies with reduced contact forces, core laminations (strips of iron placed inside the coil, against the middle leg of the core to increase the effective cross section), and the buffer spring which may be used to control the operated load of the relay and therefore the hold and release currents.

CONCLUSIONS

Although accurate manufacturing costs will not be available for some time, the new relay is expected to be substantially lower in cost. It provides major improvements in contact performance, reduced power, faster operation, and longer life. It also covers a wider field of application than any previous general-purpose relay in such characteristics as speed, slow release, marginal operation, and number of contacts. Important economic advantages include lower manufacturing cost of the relay itself and a reduction in switching systems costs resulting from the utilization of less equipment as well as a reduction in power consumption.

The new relay has shown considerable improvement in mechanical life and in contact performance; its life is of the order of one billion operations. These improvements can be expected to reduce appreciably the maintenance cost of switching systems.

Auxiliary Cables for Generating Stations

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THERE ARE THREE general characteristics of steam generating station design that distinguish this particular cable application problem from others. Maximum reliability is one characteristic. The failure of a power or control cable may cause the shutdown of a great part or all of the power station. The total cost of the cable system in an average power system will be about 1 or 2 per cent of the total station cost. Increasing the cost of the cable system would not be out of order if an appreciable increase in reliability could be obtained. In the case of a utility distribution system, an increase of 1/64 inch of insulation applies to hundreds of miles of cable and represents a major item of cost, while in a central station, it is a relatively minor item and therefore, the use of insulation classes well above operating voltage may be fully justified.

Compactness of design is another factor. One of the objects of the station designer is to keep the cubic feet of building space per kilowatt to a minimum, thus reducing building costs and steam and water piping costs, as well as cable lengths. This means that every effort is made to make it compact. Consequently, all cables are quite short and subject to sharp 90-degree bends. Further, space is limited, and there is very little room available for terminations.

Cable pan construction is a third important item. Years ago, it was the usual practice to draw every cable into its individual iron conduit. Later, cable pan construction was developed for motor and control circuits in central stations. This design consisted of installing in convenient aisles of the station one or more open top sheet steel pans or troughs, each 2 to 4 feet wide, and grouping a number of cables in each pan. Conduits were used for the last few feet from the pan to the individual items of equipment. This construction resulted in considerable saving in design, material, and installation labor. It meant, however, that special types of coverings had to be developed for cables in pans so as to give good mechanical protection and to prevent a failure of one cable in a pan from affecting others. When cables are carried outdoors, the pan is replaced by large transite pipe 10 or 12 inches in diameter, generally encased in concrete, or the cable may be buried directly in the ground. The nature of the general distribution design used has an important bearing on the selection of cable type.

The specific service conditions that must be met by some or all of the cables may be listed as follows:

1. *Installation:* Suitable for individual installation in conduit; group installation in pans or pipes, which requires a sheath with mechanical strength and toughness; direct burial in the earth for runs to the switchyard and to remote buildings such as coal handling and water supply structures.

2. *Heat Resistant:* Temperatures around the boilers, furnaces, steam pipes, and valves may well reach ambients of 50 and sometimes 60 degrees centigrade.

3. *Ozone Resistant:* For the higher voltage auxiliary motor leads, ozone resistance is essential.

4. *Moisture Resistant:* Cables carried outdoors clearly must withstand moisture. Also, those installed inside in the floor trenches or pipes or conduits in the basement floors must be able to withstand moisture.

5. *Fire Resistant:* Fires may occur from the arc following failure of a cable in a pan, but the usual rapid circuit-breaker clearance makes this unlikely. Fires are more likely to result from waste, debris, coal dust, and so forth, in cable pans being ignited accidentally.

6. *Corrosion Resistant:* Electrolytic corrosion may result from dissimilar metals under moist conditions.

7. *Suitable for Alternating and Direct Current:* The control cables will have direct current constantly impressed on them from the battery.

8. *Suitable as Vertical Risers:* There may be vertical lengths of 100 feet or more of both power and control cable.

9. *Easy to Terminate:* It is desirable to avoid both potheads and shielding.

The insulations to be considered are varnished cambric, rubber and rubberlike materials (ozone resistant, heat resistant, performance grade, moisture resistant), plastics (polyvinyl chloride, polyethylene).

The coverings that might be used are braid and steel interlocked armor, lead, lead and steel interlocked armor, lead and bronze interlocked armor, neoprene, neoprene and steel interlocked armor, neoprene and bronze interlocked armor, lead with neoprene covering, polyvinyl chloride.

Each type of insulation or covering now available has some objection when considering all the conditions it might encounter. General recommendations are to use for cable in dry pans varnished cambric insulation with steel armor or ozone-resistant insulation with neoprene covering, and for wet conditions in switchyards, varnished cambric insulation with lead covering or ozone-resistant insulation with neoprene covering.

In general, multiconductor cable for both power and control is favored with liberal cable sizes based on 100 per cent load factor and appropriate ambient temperatures.

Digest of paper **52-92**, "Auxiliary Power and Control Cables for Steam-Electric Generating Stations," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Synthesis of 2-Terminal Pair Networks

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NETWORK SYNTHESIS is the art of constructing a network whose behavior is prescribed. Usually, the term behavior refers to some particular response of the network to a particular stimulus. The network illustrated in Figure 1 is assumed to have two pairs of accessible terminals, and a response which may be of interest is E_2, the open-circuit voltage at terminals 2, when the stimulus is E_1, the open-circuit voltage at terminals 1. The behavior in this case is the transfer function of the network, defined as the ratio $E_2/E_1=\theta(p)$, a function of the complex frequency variable $p=\sigma+i\omega$. Generally, the realization of a network function includes a statement of the necessary and sufficient conditions which such function must satisfy, and a procedure for constructing the network.

An analysis on a mesh basis of the network of Figure 1, with mesh 1 taken through the left-hand pair of terminals and mesh 2 through the right-hand pair, yields the result $\theta(p)=\Delta_{12}/\Delta_{22}=J_{12}/J_{11}$, where Δ_{12} and Δ_{22} are the indicated minors of Δ, the determinant of the mesh equations, and where J_{12} and J_{11} are the open-circuit transfer impedance and driving point impedance of the network.

The relations between J_{12} and J_{11} have been given by Gewertz[1] and the properties of J_{11} have been investigated by Brune.[2] For a network containing only reactive elements, Foster's Reactance Theorem[3] specifies the form of J_{11}. Thus, it can be shown that: 1. $\theta(p)$ is a rational function of p and is real when p is real; 2. $\theta(p)$ has no poles in the right-half p plane; and 3. poles of $\theta(p)$ on the imaginary p axis are simple, with residue having zero real part. These conditions also are sufficient to realize $\theta(p)$ to within a constant factor in the canonical form of a symmetrical lattice structure. It may be observed that conditions 1 and 3 imply that $\theta(p)$ cannot have a pole at the origin or infinity.

As might be expected, when the form of the network is specified the transfer function must satisfy certain additional restrictions. Suppose it is desirable to obtain a network with given transfer function in the form of a ladder structure, with no mutual coupling between the branches of the ladder. In addition to the three conditions previously specified it can be shown that $\theta(p)$ also must satisfy the conditions: 4. $\theta(p)$ has no zeros in the right-half p plane; and 5. $0<\theta(p)<1$ when p is real and positive. These two conditions together with 1, 2, and 3 certainly are among those which the transfer function of a ladder network necessarily must satisfy. However, it has been shown that they also are sufficient to realize $\theta(p)$ to within a positive constant factor by a ladder network. If the constant factor is not too small, the undesirable attentuation may not be too serious. A feature of more concern in the method of synthesis adduced to prove the sufficiency of conditions 1–5 is the fact that with complicated θ functions superfluous elements are introduced necessarily. The network, of course, takes the form of a number of L sections connected in cascade. All but one L section of the network are constructed with inductance and capacitance alone.

The synthesis of the L network is of considerable interest for a number of reasons. To begin with, it is a constituent of the ladder structure and the properties of the latter are involved closely with those of the L network. Again, the properties of the transfer function of the L network are not as restrictive as might seem to be the case from a casual consideration. In fact, it would seem that the chief difference between the L and ladder networks is that in the simpler structure phase shifts are limited to $\pm\pi$ radians, which is not a limitation of the ladder network.

Let $\mathcal{Z}_a$ and $\mathcal{Z}_b$ denote the driving point impedances of the series and shunt arms respectively of the L network. Then the transfer function $\theta_L(p)$ is given by $\theta_L(p)=\mathcal{Z}_b/(\mathcal{Z}_a+\mathcal{Z}_b)$. From the properties of positive real functions it is easy to show that $\theta_L(p)$ must satisfy condition 5A $0<\theta_L<1$, when $\theta_L(p)$ is real in the right-half p plane. This, of course, replaces condition 5 and conditions 1–5A are the necessary and sufficient conditions which $\theta_L(p)$ must satisfy. The function $(1-\theta_L)$ also possesses these properties and when a new function, $\psi(p)=(1-\theta_L)/\theta_L$, is formed its properties can be deduced at once from those possessed by θ_L. The significant properties of ψ are: ψ has no poles or zeros in the right-half plane, and ψ is not negative real in the right-half plane. As was shown in detail, these are the necessary and sufficient conditions for a function $\psi(p)$ to be the product of two positive real functions. Hence $(1-\theta_L)/\theta_L=\mathcal{Z}_a\mathcal{Y}_b$, and the two factors can be obtained and identified with the impedances of the L structure. Thus, the transfer function of the L network can be realized simply and completely.

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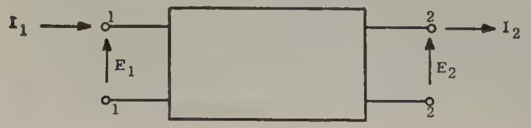

Figure 1. Two-terminal pair networks

Digest of paper 52-146, "Synthesis of the Transfer Function of 2-Terminal Pair Networks," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Technical Program Committee for presentation at the AIEE South West District Meeting, St. Louis, Mo., April 15–17, 1952. Scheduled for publication in AIEE *Transactions,* volume 71, 1952.

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Design Features of the ERA 1101 Computer

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This digital computer can perform 38 different operations. A test problem, which checks all operations performed by the machine and requires only about 0.1 second to complete, can be used during regular operation to provide assurance that the machine is functioning properly.

THE ERA 1101 computer is a single-address binary-system parallel computer using a magnetic drum memory. The word length is 24 binary digits, equivalent to seven decimal digits plus sign. The logic is quite conventional.

A machine instruction consists of an operation code plus one execution address. The execution address usually specifies the location of an operand or the place where a result is to be stored. There are a total of 38 different operations which may be grouped as follows:

Ten arithmetic operations, including regular and special additions and subtractions, divide, and multiply.

Thirteen "insert" or transmissive operations.

Four "jump" or transfer operations to allow interruption of the instruction sequence in progress.

Four manipulative aids such as logical multiplication.

Two shifting operations, each shifting left one of two registers.

Two output operations: print and print punch.

Three stops: optional, intermediate, and final.

The memory element is a magnetic drum with a capacity of 16,384 words, each 24 binary digits long. The drum, which is $8^1/_2$ inches in diameter, rotates at 3,500 rpm. The resulting surface speed of 1,600 inches per second, together with a peripheral spot density of 80 per inch, produces a basic pulse rate of 125 kc for the memory section of the machine. Although the random average access time is 8 milliseconds, an average access time of less than 1 millisecond can be obtained by placing the orders and operands in locations on the drum which will permit a number of references in the same drum revolution.

The arithmetic section consists of the X and Q Registers and the Accumulator. The X Register, 24 bits long, functions as the repository for multiplicand, divisor, augend, and subtrahend. The Q Register, also 24 binary digits in length, possesses shifting properties. This register contains the multiplier during multiplication and the quotient after a division. It also may be used as a rapid-access 1 word storage. The principal arithmetic register, and the place where the actual arithmetic is performed, is the 48-place Accumulator. It has subtracting and shifting properties.

The number representation is in a one's complement system in which the highest order binary digit designates the sign of the number. Negative numbers are represented as complements on 2^n-1, where n is 24 or 48 depending on which register contains it and on whether single or double precision operation is being used.

The basic clock rate at which the control and arithmetic systems function is 400 kc. The time necessary for addition or subtraction is 96 microseconds. This time includes procurement of both operands and the next instruction from the magnetic drum memory and assumes that the drum addresses are placed to obtain minimum access time. The corresponding time for division is 415 microseconds and for multiplication, 352 microseconds.

The computation and control sections operate asynchronously with respect to the memory. Once a storage reference has been initiated by main control, further action in this section is suspended until a "resume" is signalled by the control circuitry of the memory system.

The main sequence control receives the operation code and issues the necessary operation pulses to perform the main steps involved in the particular instruction being processed. To control the more complex arithmetic operations, such as shift, multiply, and divide, an auxiliary control system, the arithmetic sequence control, is employed.

The machine may be manually controlled from two locations. The operator's control panel contains a minimum number of controls and indicators for operating the machine. The maintenance control panel contains a complete display of indicators and switches for complete

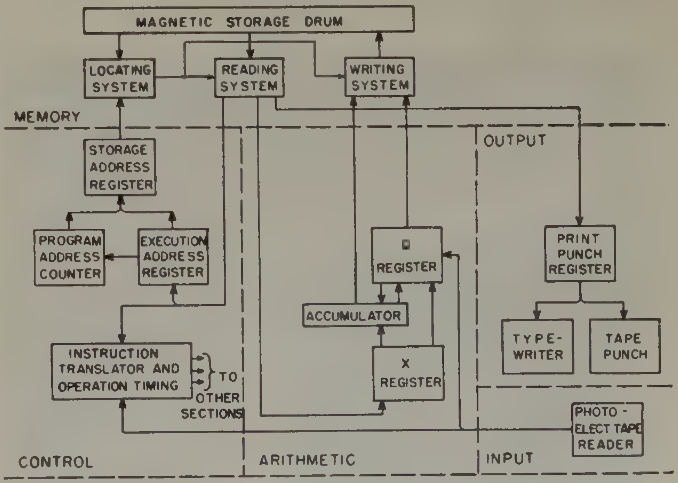

Figure 1. Principal elements of the ERA 1101 computer

Revised text of a paper presented at the Joint AIEE–Institute of Radio Engineers Computer Conference, Philadelphia, Pa., December 10–12, 1951.

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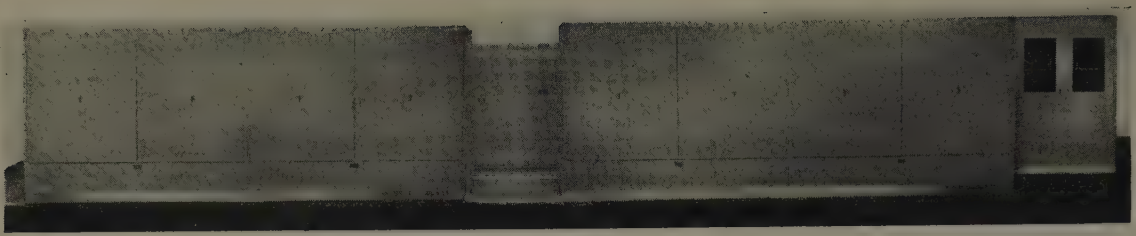


Figure 2. ERA 1101 digital computer

control of the equipment for test and trouble diagnosis.

The input medium is a photoelectric paper tape reader. Standard 7-channel perforated paper tape is used, six channels of which are used for information. Four lines, therefore, contain a 24-bit word. The seventh channel contains the coded loading instructions. This code is used to direct the operations necessary to assemble the 6-bit word pieces into the standard 24-bit size, and store them in the proper location on the magnetic drum. The loading rate is 35 words per second. At this rate, the entire drum could be loaded in less than 8 minutes if desired.

The output section consists of an electric typewriter and paper tape punch. The maximum output rate is about seven characters per second.

The output section is a potential bottleneck in most electronic computers; the ERA 1101 is no exception in this respect. However, this bottleneck can be greatly relieved if print instructions can be spaced by computational instructions. Computation proceeds immediately after the control system issues the print signal; the machine is not held up by output unless another print or punch is called for before the completion of a previous print operation.

The unusually large capacity of 16,384 memory boxes permits long-time storage of subroutines. There is no restriction on the assignment of memory boxes to order words or operands, either word type goes in any location.

"Nonvolatile" magnetic storage (long time storage of data without power in the machine) allows storage of test problems, subroutines, and function tables as long as desired.

Figure 1 shows the relationship among the various elements of the machine. The storage drum is shown at the top with its locating system, writing, and reading circuits.

To read out an instruction, the address goes from the Program Address Counter to the Storage Address Register. The locating system finds the proper address and the instruction is sent from the reading system to the control registers—the operation code to the Instruction Translator and the single address to the Execution Address Register.

To read out a number, the execution address goes to the Storage Address Register; the number is read into the X Register.

For multiplication, the multiplier is placed in the Q Register, the multiplicand in the X Register. The product is assembled in the Accumulator. After the multiplication, the multiplier remains intact in the Q Register. In division, the dividend is placed in the Accumulator, the divisor in the X Register. The quotient is assembled in the Q Register leaving a positive remainder in the Accumulator.

Additions and subtractions are made from the X Register into the Accumulator. Note also that 2-way communication exists between Accumulator and Q Register so that Q may be used as a rapid access one word storage.

A third path from the reading system is to the Print Punch Register. The typewriter (or typewriter and punch) is energized by the output of this register.

The drum is initially loaded from the photoelectric tape reader via the Q Register where the word is assembled.

CONSTRUCTIONAL FEATURES

A VIEW OF THE computer, which has an over-all leng of 43 feet including the fan bay, is shown in Figure 2. The cabinets to the right contain the electronic equipment associated with the magnetic drum memory. The cabinets to the left contain the arithmetic and control sections. In the center and behind the front row of cabinets is the maintenance control cabinet which contains the controls and indicators used in test and maintenance of the machine. The power supply is located immediately behind the arithmetic and control cabinets. The magnetic drum is behind the cabinets to the right. At the extreme right is the fan cabinet which provides water-cooled air to the other units of the equipment.

The magnetic drum is shown in Figure 3, left, with the heads in place and the cables attached. A 1/3-horsepower motor is directly coupled to the drum shaft. This drum accommodates over 200 heads and will store more than 400,000

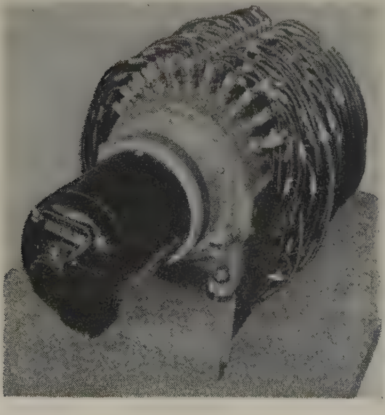
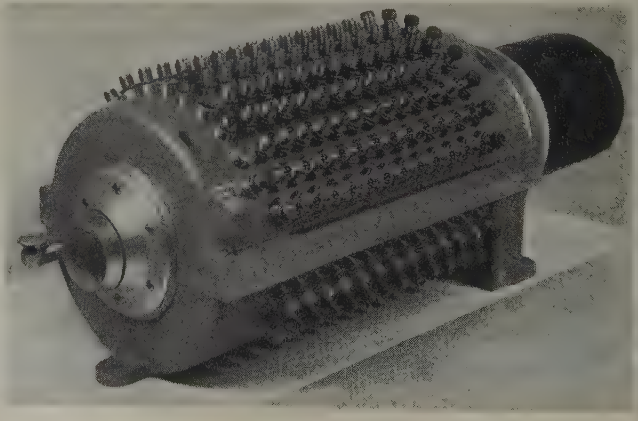


Figure 3. The 400,000-bit magnetic storage drum with (left) and without (right) the cables attached



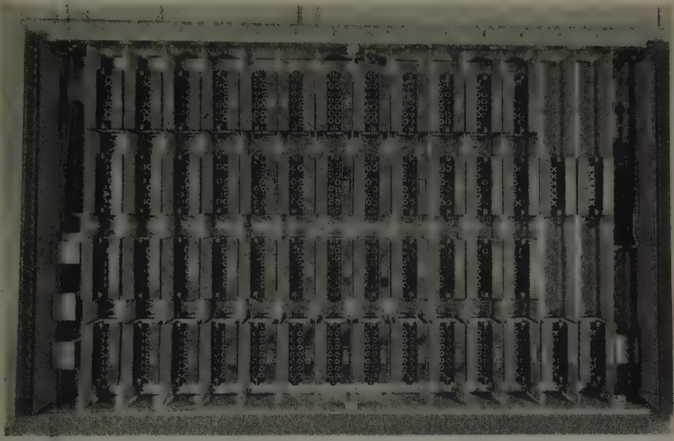


Figure 4 (left). Electronic section of storage system

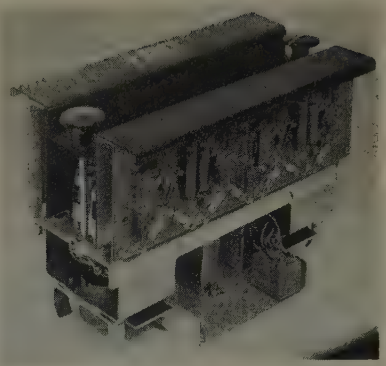


Figure 5 (right). Typical 16-tube unit chassis

binary digits. Figure 3, right, is another view of the drum. The staggered heads allow a center-to-center track spacing of 1/16 inch. An integral part of the head is a 5-pin connector.

A view of one of the electronic cabinets with the door open is shown in Figure 4. The arrangement of the plug-in unit chassis may be seen. The indicators at the top are for the 100-degree-Fahrenheit thermostats located in each channel. The formica spacers channel the air flow through the units and also provide protection against accidental short circuits when replacing units.

The standard plug-in unit, Figure 5, accommodates a maximum of 16 tubes. The design allows short lead lengths from components to connector. The component boards are placed to allow effective cooling. The pan at the bottom of the unit mounts up to five dual-section capacitors which are used for power supply decoupling. On this same bracket are mounted up to eight ERA molded pulse transformers. This unit size has proved to be convenient for quick isolation of a defective unit. The connectors are easily disengaged and the unit removed by means of a lever-operated mechanism.

Figure 6 is a view of the rear of the Arithmetic Cabinet with doors opened. It shows the back of the channels which mount the unit chassis. The filament transformers are at the top. The heater busses and the d-c service lines run vertically. The flip-flop indicator lines and the manual control lines are laced in cables. The signal wiring within the cabinet is carried on the spaced transmission lines. Pulses leaving a cabinet are sent into coaxial cables.

The power control panel is shown in Figure 7, left side. It contains metering facilities, off-voltage indicators, operating and emergency controls. The section to the right contains the electronic regulators.

The cooling system consists of water-cooled air with a plenum chamber distribution system. Figure 8 shows the fan cabinet with its filters, cooling coil, and fan. The fan has a capacity of 3,500 cubic feet per minute. The water enters at 50 degrees Fahrenheit. The air is discharged into the plenum chamber at about 60 degrees Fahrenheit. The air flow in various sections of the equipment is adjusted initially by varying the size of perforations in plates depending upon the heat dissipation in a particular section. These adjustments have very little effect on the static pressure within the plenum chamber, hence any individual adjustment has a negligible effect on the rest of the system.

A close-up of a portion of the operator's desk is shown in Figure 9. On the left is the operator's control unit. It contains a minimum number of controls and indicators and allows machine operation by comparatively unskilled personnel. Having started the computation, the operator can stop the machine only at programmed stops. To the right is shown the photoelectric tape reader. The tape passes between the lamp housing and the light gate which consists of pulse shaping apertures. The light passing through those apertures which line up at any particular time with holes in the passing paper tape, impinges on the ends of lucite rods which transmit the light to miniature phototubes. A removable chassis contains amplifiers which bring the signals up to the standard output level.

TESTING AND MAINTENANCE

THE CONTROL PANEL, shown in Figure 10, contains the indicators and switches needed for complete control of the equipment. The machine is operated from here for program trouble shooting, testing, and maintenance.

Every flip-flop has indicators on both sides. Each digit of a register has a push button for manual setting during test. One group of toggle switches allows certain control lines to be disconnected to permit cycling of normally nonrepetitive operations.

Another group of switches permits reduction of heater voltages by sections as a marginal checking aid. We do

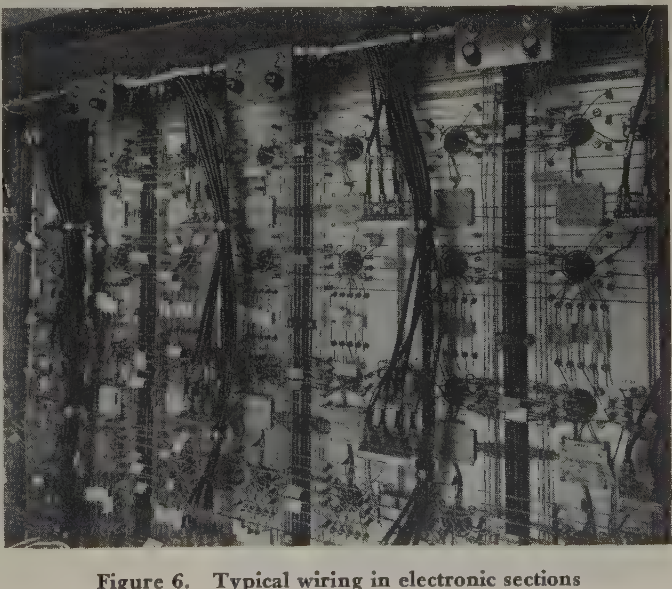


Figure 6. Typical wiring in electronic sections

not feel that heater voltage reduction is the complete answer to marginal checking problems. It has, however, proved extremely valuable in providing a safe margin of operation. Failures rarely occur during operation.

A self-checking test problem is used in conjunction with the reduced heater voltage tests. It checks all of the machine's operations. If there is a failure in any individual test, operation halts. The address held in the execution address register at the time of the stop indicates in which test the failure occurred. Slow speed and step-by-step operation pin-point the cause of the trouble.

This problem also may be used during regular operation to provide assurance that the machine is functioning properly. It is inserted automatically at intervals during the course of a computation. The time needed to execute the test problem once is about 0.1 second.

All components are operated well within manufacturers' ratings. Maximum tube dissipation is limited to 50 per cent of rating. Resistor dissipation is limited to less than 35 per cent of rating. Crystal diodes, with few exceptions, are not subjected to inverse voltages greater than half of the manufacturer's rating, nor are they required to conduct direct currents greater than 50 per cent of the ratings.

The protective features of the equipment include cabinet interlocks, air-stream monitor, and two levels of thermostatic protection in each cabinet.

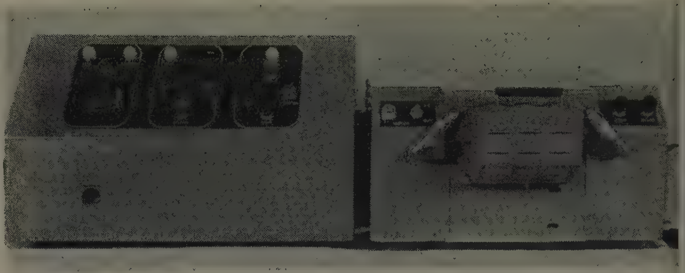


Figure 9. Operator's control station and photoelectric tape reader

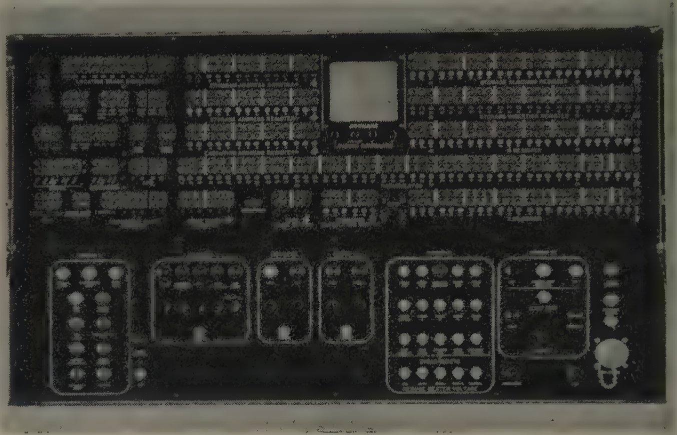


Figure 10. Maintenance control panel

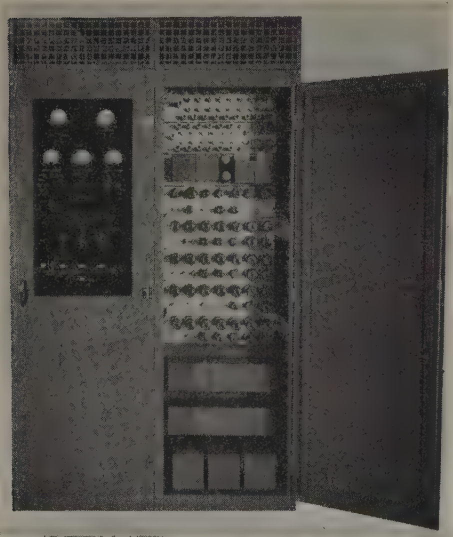


Figure 7. Power supply and control

Figure 8. Fan cabinet, interior view

OPERATIONAL RECORD

The first ERA 1101 was delivered in December 1950. It was unpacked, installed, tested, and ready for operation in only eight days. The maintenance personnel assigned to the machine are not employed by ERA nor are they under its supervision. Only two of them had seen the equipment before its delivery. The operating record being achieved is without doubt a tribute to the abilities of the maintenance group and also speaks well for the design of the machine. For the first 7,100 hours of "heater on" time the equipment was available operationally 87 per cent of the time, 10 per cent was used in scheduled preventive maintenance and marginal checking, only 3 per cent was spent in unscheduled maintenance.

ERA 1101 features felt to deserve perpetuation are

1. A plug-in chassis of about the same size.
2. A maintenance control panel. This panel could be a section of the operating console, but should be definitely separated from the strictly operational controls.
3. A magnetic drum for a large-capacity nonvolatile memory.
4. For cooling, an air-to-water heat exchanger with plenum chamber air distribution.
5. Protective devices as thermostats, air-flow detector, off voltage, and overcurrent protection, to name a few.
6. Conservative component deratings.
7. The general layout of the interchassis wiring.
8. Self-checking test problems plus adequate marginal checking provisions.

Functional Evaluation of Motor Insulation Systems

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AT PRESENT, all insulating materials are classified by chemical composition into groups with specified maximum operating temperatures. Because many materials, especially those in the organic group, differ widely in their stability toward heat aging, these definitions have become too restrictive. To replace this system, a new method of classification is proposed based on the ability of a material to perform an insulation function. This method is intended to apply specifically to random wound induction motors in the approximate range of 1 to 40 horsepower or to equipment using a similar insulation system.

In this proposed evaluation, materials to be classified are assembled in a test unit and given an accelerated life test.

The test unit has the exact slot dimensions of an actual motor and employs electrical and insulation elements (including varnish treatments) of this motor as far as practicable. The finished unit is compact, easily handled, and inexpensive.

The test unit ("model motor") before assembly is shown in Figure 1. Two metal plates holding the insulation components (slot, phase, and wedges) and wire are bolted to a supporting stand. A terminal block also is attached to the supporting stand to allow electrical testing without flexing coil leads. Each coil is made up of two parallel wires to facilitate turn-to-turn testing and the lead ends are protected by tubing. A completed unit is illustrated in Figure 2.

A cyclic life test in which the deteriorating effect of aging at elevated temperatures is the main accelerating factor is proposed. Vibration and conditioning at high relative humidity are included principally to make this deterioration evident at test voltages approximating those present in an operating motor. Since the service life of a motor in the field is terminated when the motor fails at operating voltages, failure at similar voltages is taken as the end point for the test.

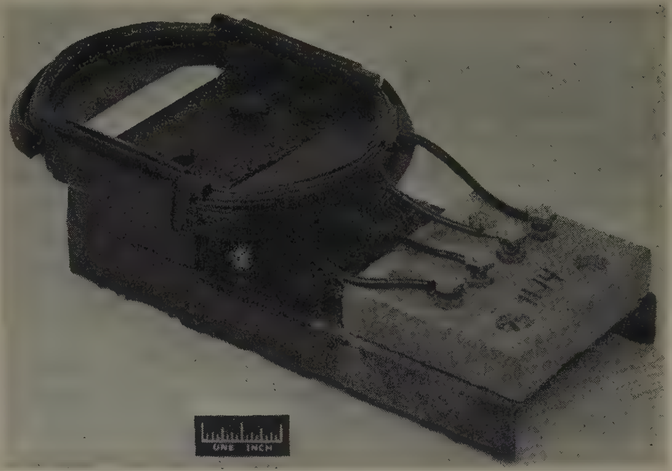

Figure 2. Model motor after protective coating treatment

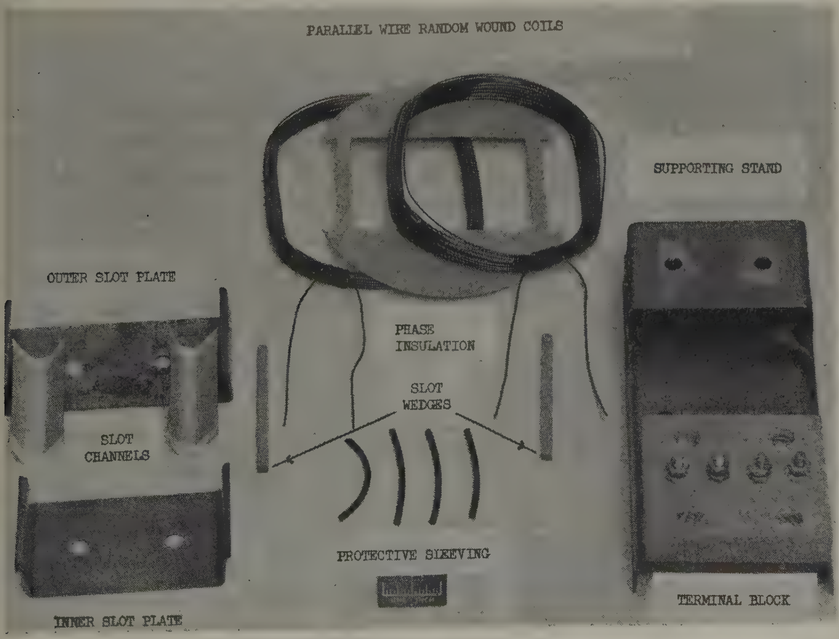

Figure 1. Components of model motor before final assembly

At the end of exposure to heat aging, the test unit is vibrated and then humidified to complete 1 cycle. After each step of this cycle, electrical check tests are made between turns, coils, and to ground. These cycles then are repeated until failure occurs during any electrical check test.

By the procedures outlined, it is expected that the relative lives of a wide variety of insulation systems under any specific service conditions can be determined more quickly and less expensively than is possible by present methods. Comparisons of data from such tests with the records of service experience should enable test cycles to be established in the future that will represent any specified service conditions. If this can be done, it may be possible ultimately to assure any desired service life expectancy by specifying that the insulation system withstand a certain number of cycles of a test procedure similar to that outlined in the article.

Digest of paper **52-57**, "Functional Evaluation of Motor Insulation Systems," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Calculation of Carrier Current Attenuation

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CARRIER CURRENT on a power line is generally an improperly terminated transmission line since rarely, if ever, do busses, transformers, and other connected power apparatus load the transmission line with its characteristic impedance. The characteristics of such a line are a function of frequency, length, and the impedance of all connected apparatus and therefore can be extremely complex. However, with all factors known, these characteristics could be computed, but that involves far too much labor and time to be practical from an engineering standpoint.

Carrier-current transmitters and receivers are designed to work together through a definite maximum attentuation. The practical maximum attenuation is usually less due to the presence of carrier frequency noise on the transmission line. Whether a given system will work depends on the attenuation between the transmitter and receiver, and the noise at the receiving point. It is, therefore, imperative that some idea of the attenuation between the points in question be obtained before applying carrier current to a system.

Until now estimations of attenuation have taken account of frequency, length, and the characteristic impedance of connected lines, but not the input impedance–load impedance characteristics of lines, or the effects of connected power apparatus, in particular power, potential, and current transformers. Recent data indicate that the effects of power transformers certainly should not be ignored.

Development of this method followed several steps beginning with the fundamental transmission-line equations. The goal was a method based on these fundamental equations, modified and simplified to the point where the time involved in their solution was reasonable from an engineering standpoint.

The various losses which are encountered on a carrier system have been separated, and tied in mathematically with line impedance levels as well as the impedances of certain power equipment. These losses break down into two general mathematical equations which may be solved readily by means of curves such as Figure 1. Curves also have been developed which show the input impedance of a transmission line as a function of its load impedance and attenuation. The relative impedance levels throughout a system then may be established, and the individual losses determined.

It should not be necessary to add a safety factor to the results. Considering all impedances as resistive automatically adds a factor of safety since reactances do not absorb power. This factor of safety is then a function of the number of untrapped lines, busses, and transformers which, in turn, determine the risk involved in putting carrier on any particular line. Obviously a fully trapped system needs less safety margin to take care of variables than does an untrapped system. It is felt that this is one advantage of the method presented here. Though there are many assumptions and approximations, it is felt that the results obtained more nearly portray the conditions of the line and the attenuations to be expected than do older approaches to the problem.

There are two main difficulties standing in the way of exact solutions to these problems. One of these is a lack of information about factors such as the effects of sleet on line attenuation, and the characteristics of connected power equipment. The second is, of course, the time involved in solving the basic equations. Future work, therefore, probably should follow two steps: first, determination of power apparatus characteristics and the effects of weather conditions, and second, development of a calculating board on which data may be set up and attenuations measured, without the necessity for long, drawn-out calculations.

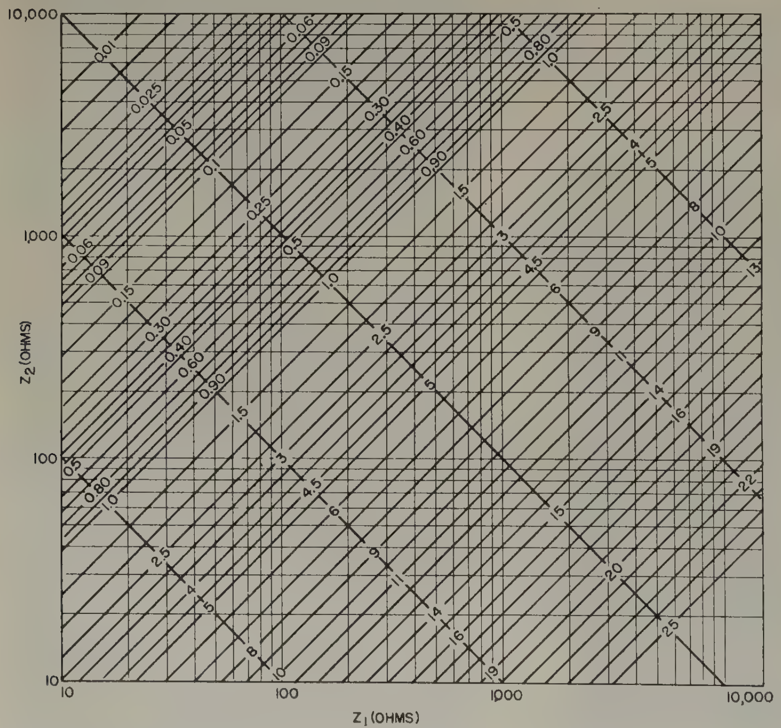

Figure 1. Solution of $db = 10 \log \frac{Z_1 + Z_2}{Z_2}$

Digest of paper 52-217, "New Method of Calculating Carrier Current Attenuation," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Re-examination of Temperature Standards for Electrical Insulation

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Information is presented which indicates that standards are still inadequate to differentiate clearly the temperature classes of insulation and several changes are suggested to improve and broaden those standards.

WHEN INSULATIONS were first classified[1,2] as to limiting temperatures, definitions were relatively simple as all of the basic components existed in nature. No synthetic or truly man-made materials were employed at that time. Therefore, the materials fell readily into two classes: 1. organic and 2. inorganic. Temperature limits for the insulation classes were selected at first on the basis of simple tests, but the classification was largely determined by whether organic or inorganic components were used. Subsequently, it was recognized that organic materials fell into two different temperature classes based on whether they were composed entirely of fibrous organic constituents, Class *O*, or whether the fibrous components had additional protection from thermal aging by impregnation with varnishes or by immersion in oil. The inorganic components, which were described under Class *B* definition, mica and asbestos, had very obvious uses. Mica was then the only possible inorganic dielectric barrier, whereas asbestos could be used only as a separator on low-voltage parts or as a binder and structural member. The question of functional evaluation of insulation did not occur to the engineers who made the original classifications as little or no opportunity for such a choice existed.

With the advent of man-made molecules in numerous synthetic materials suitable for use as electrical insulation, the problem of classifying insulations according to the original definitions has become a very puzzling one. It has become apparent that materials can no longer be defined simply as "organic" or "inorganic" even if the intermediate class of "semi-inorganic" is added. It has been found that even truly organic materials as designed and fabricated by the chemists have vastly different levels of thermal endurance, as well as differences in their physical properties both between themselves and from those organic materials occurring in nature. It, therefore, becomes desirable to re-examine the definitions of insulation classes in AIEE Standard Number *1* in order to make a more realistic appraisal of presently available materials; and to provide more suitable means for classifying them and the materials as yet to be developed.

FUNCTIONAL EVALUATION

IT IS THE AUTHOR'S opinion that insulation temperature limitation should be established with due consideration given the function which the insulation must perform in the apparatus. To accomplish this it is proposed that the AIEE Standards recognize that insulating materials have three distinctly different uses in electric apparatus:

1. To provide dielectric strength by barrier action.
2. To provide physical separation across creepage surfaces or through a porous structure.
3. To provide physical support and surface binding.

It is imperative that the insulation used for the major ground insulation wall on machines provide suitable dielectric barrier action,[3] or that very long creepage surfaces be employed. Turn-to-turn insulations for low voltage may provide only separation for low-voltage duty and, therefore, relatively small creepage distances are frequently adequate. However, on the higher voltages, where turn-to-turn stresses are high, a dielectric barrier may be required between turns. Where the insulation's main function is physical support, dielectric barrier action may be of little importance as that is usually provided by other insulation components. The opinion has grown in the electrical engineering profession that an insulation may be entirely suitable for one of these three applications and not for others under similar temperature conditions. When considered from the viewpoint of thermal aging, this leads to the conclusion that material should be classified thermally according to how well and how long it can perform its intended functions under the conditions of thermal aging encountered on specific applications.

AIEE Standard Number *1* is subject to many varied interpretations for several classes of insulation. This is particularly true of Classes *B* and *H*. As a member of the working group which revised this Standard for the 1947 issue, the author feels free to criticize this part of the basic insulation concepts and urge further changes to clarify and improve it. One example of the inconsistencies and misinterpretation lies in the use of the "fiber glass." The definition reads: "Class *B* insulation consists of mica, asbestos, fiber glass, and similar inorganic materials in built-up form with organic binding substances. A small portion of Class *A* materials may be used for structural

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Full text of paper **52-166**, "The Re-examination of Temperature Standards for Electrical Insulation," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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purposes only." By one interpretation varnished fiber-glass cloth fits this and, therefore, could be used as major ground insulation. Yet experience has demonstrated that not all varnished fiber-glass cloth has suitable thermal endurance to provide dielectric barrier action when operated at the permissible Class *B* temperature. On the other hand, few engineers will question the suitability of fiber-glass-covered and varnished wire as a satisfactory Class *B* turn or strand insulation where the operating stress is 50 volts or less per turn. In the case of the varnished fiber-glass cloth, it is important to recognize that it is the insulation level of the varnish as a dielectric barrier after thermal aging which should determine the temperature class of the insulating material or insulating system. In the case of the glass-covered wire, the varnish serves only structural purposes and can be relied on to preserve physical support and spacing long after its varnish film is no longer a dielectric barrier. However, in most instances the bond is not intended to contribute to the dielectric strength.

CURRENT CONCEPTS AFFECTING INSULATION TEMPERATURE LIMITS

Following are several ideas, widely held by insulation engineers, which affect decisions as to changes in temperature limits:

1. Tests on insulation in the "as made" condition are not sufficient to demonstrate its suitability for service under the present temperature class definitions.
2. Suitability for service at specific temperatures should be determined on the basis of the particular requirements depending upon whether the electrical, mechanical, or chemical requirements predominate.
3. Insulating materials may have several different temperature limits depending upon which properties are being utilized in different applications.
4. Accelerated thermal aging tests have become a recognized tool for quick but limited evaluation of thermal endurance. However, accelerated test data should be supplemented with long-time tests at approximately normal temperature extending over an appreciable percentage of the expected or desired minimum life of the insulation system.

DIVERSIFIED THERMAL AGING TESTS

Thermal endurance studies by investigators[4–10] have made important contributions to the background of thermal aging of insulation. Information contained in papers by Mathes,[11] and Cypher and Harrington[12] presents some very interesting and significant data on functional evaluation of complete insulation systems. Such work should be continued and expanded. However, it must be recognized that all of these studies have evaluated specific insulation systems. They do not solve the basic problems of defining and classifying the materials. It would be possible to make broad conclusions from much of the existing test data, concerning general classes of insulation which may be misleading unless the basic materials are first defined and classified more clearly than the existing Standard Number *1*. Two points of view are essential to a complete understanding of thermal aging: 1. Individual materials must be classified according to their specific functional evaluation; and 2. Insulation systems must be evaluated functionally as a whole for specific duty requirements.

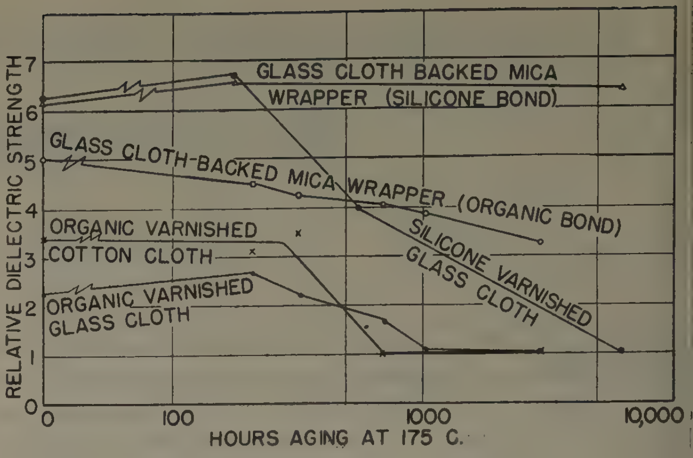

Figure 1. Effect of thermal aging and humidification on relative dielectric strength of insulating wrappers in test bars

It is important to know the inherent limitations of a material and how thermal aging affects its electrical and physical properties with reference to each of its three possible kinds of usage in insulation systems. When this has been determined, the functional evaluation of an insulation system containing this and other components will take on greater significance.

Such a comprehensive program presents many problems and will require the co-ordination of many diverse points of view as well as the accumulation and analysis of a great deal of test data. The first step is to agree on objectives and definitions.

THERMAL AGING DATA ON DIELECTRIC BARRIERS

As a contribution to this point of view, tests were conducted to study the effect of thermal aging on a series of coil wrappers, such as used for ground insulation on armature coils. These include cotton and glass cloths with organic varnish coatings, glass cloth with silicone varnish, and glass cloth-backed mica wrappers with both organic and silicone varnish bonds. These materials were applied to test bars to simulate coil structures. All were evaluated as dielectric barriers using step-by-step 1-minute a-c tests to failure as a function of time at 175 degrees centigrade with humidification after aging. Data are presented in Figure 1 where relative dielectric strength is plotted against time of aging. Unity for relative dielectric strength is the voltage required to break down the physical separation where no dielectric barrier action exists.

All varnished fabrics in this series of tests indicated definite signs of thermal aging as measured by loss in dielectric barrier action. The differences between the cloths were only a matter of degree. Referring to the data on organic-varnished cotton and glass cloth, the contribution of the glass cloth is too small to justify differentiating in the standards, yet by some interpretations of AIEE Standard Number *1* fiber glass cloth with organic varnish coating is considered a Class *B* dielectric barrier.

Both Class *B* and Class *H* mica wrappers exhibit initial values and retention of dielectric barrier action far beyond that obtained from the organic-varnished cloths used in these tests. It is significant that although the initial insulation level is high, the silicone-varnished glass cloth, Class *H* by definition, lost its dielectric barrier action at a faster rate than the Class *B* mica wrapper.

This information is offered in support of the position that present definitions are inadequate to differentiate clearly temperature classes of insulation and that some revision of Standard Number *1* should be undertaken.

PROPOSED CHANGES IN INSULATION STANDARDS

THE FOLLOWING SUGGESTIONS are presented for discussion and development as contributions to broadening and improving insulation standards. It is hoped that they will help in realistic evaluation of current insulating materials and systems. These should be of greater value in fitting newer materials in their proper engineering and economic fields.

1. Recognize the three uses (separation, dielectric barrier, and physical support) of insulating materials in apparatus with respect to evaluation of temperature stability, and differentiate between the requirements for each.
2. Define insulation temperature classes in relation to functional evaluation of materials for specific time-temperature relation to reach certain levels of physical and/or electrical strength.
3. Establish recognized tests for functional evaluation of the thermal endurance of insulation systems for specific service conditions.
4. Require comprehensive testing of new materials and systems under standard test methods before classifying as to thermal endurance rather than "reading them into" a general class by definition.

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Two Thousand Feet of Seam Inspected With One Radiographic Shot

Two thousand feet of welded seam that secure a 48-foot Horton sphere at Polymer Corporation plant, Sarnia, Ontario, Canada, was inspected with just one radiographic shot last month. Isotope Products Limited performed the job by employing a new inspection technique developed by Dr. T. Pepper. He headed the Isotope crew which made a complete radiographic record of the sphere welding on 1,500 sheets of film.

The Horton sphere is used for storage of liquified volatile hydrocarbons under pressure. It is typical of hundreds of industrial tanks and reservoirs which require thorough inspection periodically. Such inspection involves careful examination of every inch of welding over vast surfaces. The Isotope Products technique is aimed at performing this gigantic job in minimum time. The Polymer project was its first application. This month Isotope personnel will apply their new technique of multiple radiography on a large oil storage tank.

Polymer's inspection department believed that radiographic examination of the sphere could be done in one operation and asked Isotope to develop the technique.

At Sarnia the 1,500 films were loaded into lightproof holders. Loading took 48 man-hours. Each holder was marked with an identifying lead number which indicated its exact position on the tank. Holders were stapled to tough plastic backing strips which were cut to fit welds. Strips were attached along welded seams with heavy tape.

To record the weld image on the 2,000 feet of film, approximately 100 curies of iridium 192 was used. This isotope source was suspended on a chain which dropped it from the shielded lead castle in which it had been transported and lowered it into the tank. The source was lowered through a top central manhole and suspended in the middle of the sphere.

The iridium source was left in position 16 hours. During this exposure time, test films were removed at intervals and processed to determine exactly the correct exposure.

After exposure the isotope source and film were removed. It took just 2 hours to remove the film from the sphere. The film was then unloaded, developed, edited, interpreted, and filed. Nine days after its arrival at Sarnia, the Isotope crew had completed the project and reported its findings. This time included subsidiary radiography shots of special areas. Radiographs of every weld, including some 500 feet of welds with backup strips, and of nozzles and manholes were produced. Many trepan inspection points and flanges were inspected as well.

Attaching of film and later stripping it from the sphere was a co-operative job that involved both Isotope personnel and personnel of Polymer's inspection department.

Interlaminar Insulation Test for Stators

H. R. TOMLINSON
MEMBER AIEE

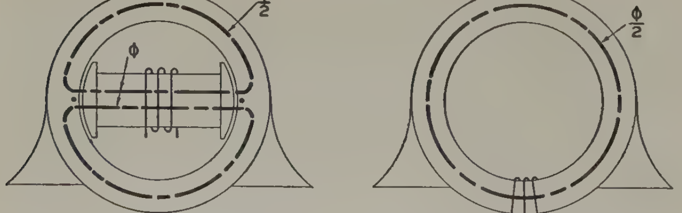
IT IS OFTEN DESIRABLE to test the effectiveness of the interlaminar insulation in a generator stator. Iron damage may be sustained as a consequence of mechanical abrasion or arc burning during a winding insulation failure. A simple flux test can be made to determine if the interlaminar insulation has been impaired within a damaged area which might develop into a hot spot when the machine is restored to service.

An effective test can be made after the rotor has been removed by winding around the stator iron a magnetizing coil having sufficient ampere-turns to produce a flux based on one-half the average turn voltage of the main armature winding. Experience indicates that with this flux density, heat will develop at any spots where the interlaminar insulation is not in the proper serviceable condition.

The basis for the design of this test coil is explained by referring to Figure 1*A*, which, for simplicity, illustrates a simple 2-pole machine having an armature coil with sides in the center line of the field poles. The flux produced in operation by the field generates E_t volts per turn in the armature winding. This field flux has two parallel circuits in the stator. Therefore, a magnetizing winding around the stator having $E_t/2$ volts per turn, as in Figure 1*B*, will produce an equal number of flux lines in the stator iron.

Any convenient supply source at the generator frequency may be used for the test winding. It is necessary only to install the required turns so that the volts per turn of the test winding when energized from the test source is equal to one-half the average turn voltage in the main winding as that which is determined from the manufacturer's winding data.

It also is important to estimate the probable kilovolt-ampere demand on the supply source. The ampere requirement for this test winding depends upon the saturation characteristics of the stator iron and its mean diameter. For machine stators having mean diameters of 4 to 7 feet, the magnetizing of the stator at the $E_t/2$ value requires 1,200–2,100 ampere-turns. Hence, an approximation of the ampere demand can be made by dividing a judgment figure of between 1,200 and 2,100 based on the stator diameter by the number of turns which have been selected for the test coil.



FIELD FLUX ϕ GENERATES E_t VOLTS PER TURN IN MAIN WINDING
(A)

$\frac{E_t}{2}$ VOLTS PER TURN ON TEST COIL PRODUCES $\frac{\phi}{2}$ FLUX IN STATOR
(B)

Figure 1. Elementary diagram of core magnetization for synchronous machine

In some cases it is desirable to install a transformer between an available supply source and the test coil in order to obtain a balance between required volts per turn and ampere demand.

It is recognized that the flux produced by this test may or may not be an approximation to normal operating flux density, depending on other winding factors, such as coil pitch and distribution factor. The nearer these factors are to unity, the nearer is the approximation to normal flux density. However, this test can be extended to the normal flux level, particularly when the test coil as determined by the foregoing consists of only a few turns, by the removal of one turn. If the ampere demand then increases greater than the inverse ratio of the turns squared, the magnetization of the stator approaches saturation and hence, is within the region of operating density. With a magnetizing winding of many turns, it may be necessary to remove several turns in order to approach the operating flux level.

On one occasion, the test made during a maintenance overhaul indicated impairment of insulation in several teeth. Repairs were effected by the insertion of new insulation.

A sample calculation for magnetizing the stator of a modern 75,000-kva 3,600-rpm turbogenerator and the results of the test are given here:

Rating: 75,000 kva, 3,600 rpm, 14,400 volts, Y-connected.

Winding Data: Two parallel coils, each 11 per phase; one turn.

Calculations: Average volts per turn $=14{,}400/\sqrt{3}\times 11\times 1 = 760$. Required volts per turn of magnetizing winding $= 760/2 = 380$ volts. A 2,300-volt station service source is available. Therefore, magnetizing winding should have $2{,}300/380=6$ turns. Estimated demand $= 2{,}100/6=350$ amperes $=800$ kva.

Test Results: With 2,360 volts on a 6-turn winding of 250,000-circular-mil cable, 335 amperes flowed, resulting in a magnetizing force of 2,000 ampere-turns. With five turns, 650 amperes flowed, resulting in a magnetizing force of 3,250 ampere-turns. 650 is greater than $335\times 6^2/5^2$ $(=485)$.

Digest of paper **52-174**, "Interlaminar Insulation Test for Synchronous Machine Stators," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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D-C Motor Losses With Rectifier Operation

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THE USE OF grid-controlled rectifiers for the supply of controlled power to d-c machinery has raised the problem of the increased losses in motors used in this way. The output of a grid-controlled rectifier has a large ripple voltage, the waveform of which varies with the firing delay caused by the grid control. This ripple causes alternating currents to flow in the motor which do not add to the rotational power produced but which cause additional copper loss. In addition, another component of flux is created in the magnetic circuit which causes additional hysteresis and eddy current losses.

To analyze the a-c conditions it was decided to express the rectifier output voltage as a Fourier series, calculate the current due to each component, and add the components using the principle of superposition. The limitations of the superposition principle to linear circuits is well known, and it is realized that the magnetic circuit of a machine is not linear; it was decided to use this principle in an effort to get first-order approximations of the alternating component.

To test the validity of the theory tests were run on a small d-c shunt motor. First, standard tests were run using steady direct current to determine normal losses; then tests were made with the motor operating from a grid-controlled 3-phase half-wave rectifier and the increase in losses was determined experimentally.

The investigation made here is limited to the case of continuous currents. Under these conditions the rectifier output voltage could be expressed as a Fourier series having a direct component and 180- and 360-cycle components.

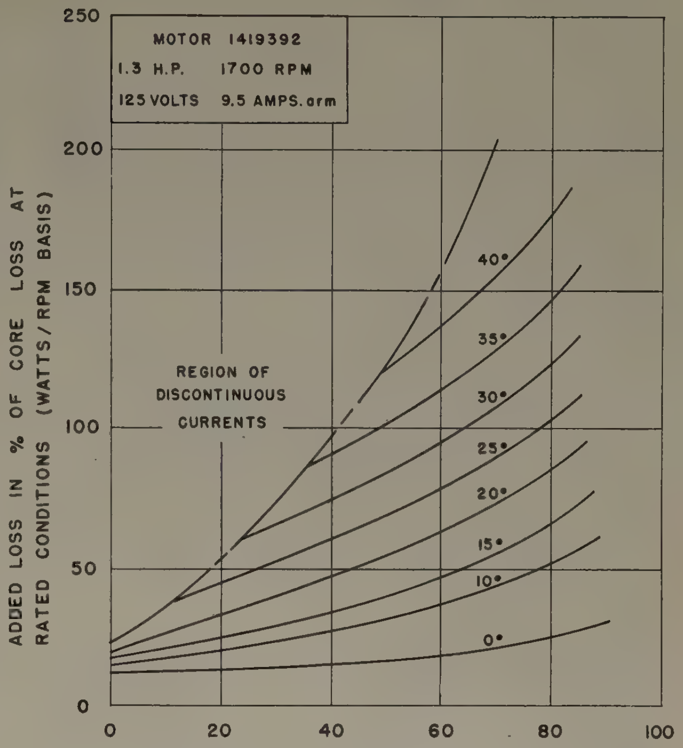

Figure 2. Added iron losses

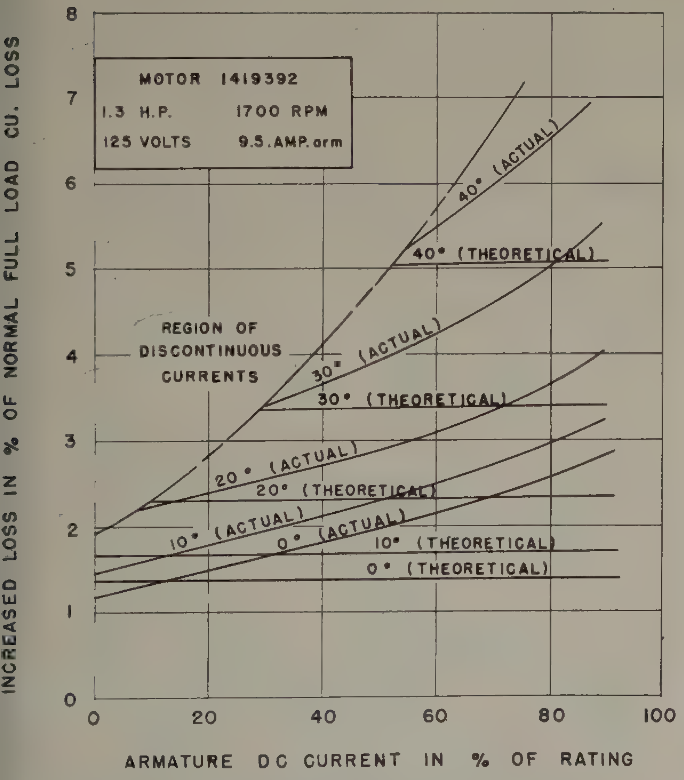

Figure 1. Added copper loss due to ripple current

The armature circuit inductance was determined from 60-cycle impedance tests made under conditions of normal field excitation. Using the rectifier and motor constants the voltage and current of each component is calculated. The ripple current would be constant for any load at a given delay, according to this method; actually the ripple at various delays increases slightly with load.

Theoretical and actual copper loss increase is plotted in Figure 1. Here it is seen that the prediction closely approximates the test values, although there is some increase in copper loss with an increase in load.

The iron loss increase with alternating current flowing in the armature circuit is almost impossible to calculate. Intuitively it would seem that the larger the component of ripple current, the larger the increase in iron losses. Figure 2 shows the results of tests on the motor which bear out these expectations.

Digest of paper 52-74, "Increased Losses in a D-C Motor When Operated From Grid-Controlled Rectifiers," recommended by the AIEE Committee on Industrial Control and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21–25, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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Frequency-Shift Carrier-Current Equipment for Telemetering and Other Control Functions

R. W. BECKWITH
MEMBER AIEE

The frequency-shift crystal oscillator and the crystal discriminator, which are vital to the channel equipment utilized, are described here. The former is used to generate the carrier signal and the latter is used in the receiver to reform the transmitted intelligence.

THE substantiated theories of frequency modulation[1] have been extended to the transmission of coded and other types of low-frequency signals. A very-narrow-band frequency-shift power-line carrier-current system has been developed. Theoretical work has been done, sample circuits have been built, and the simplest ones have been selected. Transmitters and receivers have been produced in sizeable quantities and applied to power-line use. The first of these now have had several years of successful operation. As a result of field experience, additional development work, and new operating requirements, an improved transmitter and receiver have been designed.

In the frequency-shift transmitter, a Hartley oscillator is modified by the introduction of a network of two crystals in the feedback circuit to the grid. An explanation of this circuit operation is given later, and it is shown that oscillation is controlled by the crystals at two frequencies and that operation can be shifted smoothly from one of these frequencies to the other by means of a variable-reactance circuit connected across the oscillator tuned circuit.

As a receiver demodulator, a single crystal is used in a bridge circuit along with diode rectifiers to produce a true crystal discriminator[2] having all the characteristics of a conventional discriminator except with a greatly magnified frequency scale. An improved form of this circuit, having better efficiency and freedom from effects of interfering signals, is described in later paragraphs.

The first circuit is used to form a frequency-shift signal, keyed at rates up to about 30 cycles per second. The percentage shift in frequency is kept very small to conserve frequency spectrum, and the second circuit is used to detect this small shift in frequency. This combination forms a channel having excellent properties for transmission of telemetering signals.

As a by-product of this development has come the application of the equipment to form a new type of channel for transferred tripping. This already has proved, by field tests, to be highly successful and much more reliable than previous systems. A second by-product, a new method of transmitting load-control signals, also promises to be very successful. A third application provides a most reliable channel for supervisory-control functions.

In order to appreciate the design considerations for this equipment it is first necessary to understand the characteristics of the various signals to be transmitted. In all of the cases the intelligence is represented by some sort of code. They are as follows.

Telemetering.[3–5] This classification is the most common and may be any one of three types:

1. Impulse duration telemetering[6] consists of on-off cycles of uniform total length (2.4 seconds in one typical case) in which the on-off ratio is the measure of the telemetered quantity.
2. Impulse rate telemetering uses equal on and off impulses but of varying rate (up to four per second in some cases). In both of these first two types the carrier-current transmitter is keyed by a contact, and a relay in the carrier-current receiver must duplicate this performance.
3. Variable-frequency telemetering[7] uses 6 to 27 cycles per second in a typical case. The carrier-current transmitter is keyed by a voltage, and the receiver must duplicate this voltage in frequency but not necessarily in waveshape.

Load Control. In order to control a generator governor remotely, it is necessary to duplicate at the carrier-current receiver the action of single-pole double-throw contact. It may stand open in both directions, close in one direction for a "raise" impulse, or in the other direction for a "lower" impulse. These impulses may be of about 1 second duration. Several of these impulses are sent to make a required change in generation, rather than one continuous impulse.

Transferred Tripping.[8] In certain protection schemes for high-voltage transmission lines, it is necessary to transmit a carrier signal which will result in the tripping of a remote circuit breaker. Fast operation is required, that is, a contact should be closed at the receiver less than 33 milliseconds after one is closed at the transmitting end. A unique requirement is that the equipment may not be called on to operate, other than for routine tests, for a period of years. At the same time, however, utmost reliability is demanded, since correct operation at the proper time will prevent damage which could run into a figure many times the cost of the carrier-current equipment.

Revised text of paper 52-218, "Frequency-Shift, Carrier-Current Equipment for Telemetering and Other Control-Type Functions," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Minneapolis, Minn., June 23–27, 1952. Scheduled for publication in AIEE *Transactions*, volume 71, 1952.

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This article is based on a thesis submitted to the faculty of Syracuse University in partial fulfillment of the requirements for the degree of master of electrical engineering.

Supervisory Control. The supervisory control equipment manufactured by the General Electric Company[9] requires the transmission of a code and the simultaneous reception of a proper interposing code from the other stations. Assume, for example, a fault on a tie line causes simultaneous circuit-breaker operation at controlled stations *B* and *C*. In reporting back to master station *A*, this interposing code from *B* will cause *C* to wait for a free period to report its operation. In order to conserve frequency space and carrier equipment, keyed carrier and a single-frequency channel are usually used. In this way the receiver at each point responds to signals from all other stations.

An analysis of the various signals to be transmitted showed that the channel must be capable of handling a band of frequencies from 30 cycles per second down to and including d-c transmission. Two circuits described in this article form the heart of the channel equipment. These are the frequency-shift crystal oscillator, used to generate the carrier signal, and the crystal discriminator, used in the receiver to reform the transmitted intelligence.

FREQUENCY-SHIFT OSCILLATOR

THE FIRST APPROACH to the problem of producing a frequency-shift signal was the rather obvious method of using two crystal-controlled oscillators and providing a means of switching the output. In this, two crystals in conjunction with a double triode formed two Pierce oscillators. The output controlled by one crystal drove one buffer stage and a second crystal oscillator drove a second buffer. Both buffers were connected so as to drive an output tube and a means was provided for switching the two buffers alternatively on and off. As a result, the output tube was first driven at one crystal frequency and then at the other.

This method was satisfactory as long as the keying rate was low compared to the shift in carrier frequency. As the keying rate was increased, however, an interesting phenomenon occurred which prevented the realization of keying speeds compatible with the bandwidth being used. In other words, a deviation ratio (ratio of highest modulating frequency to half the shift in frequency) of unity was impossible.

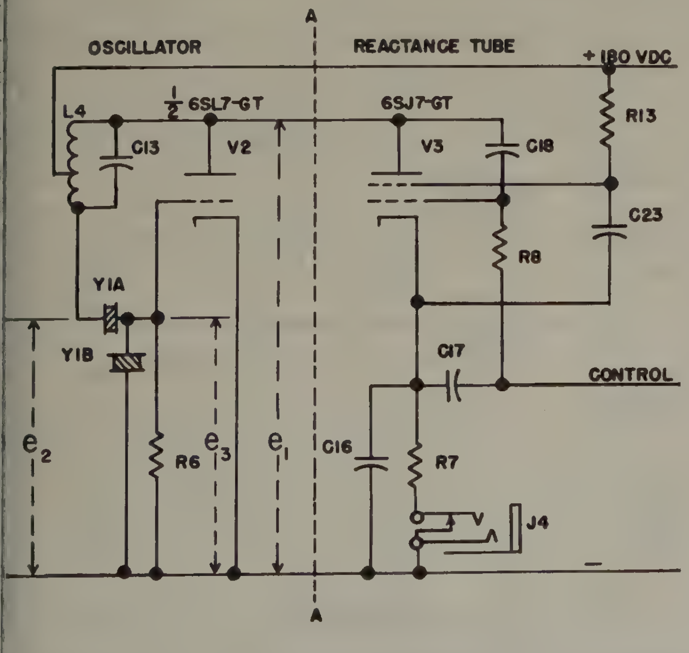

Figure 1. Frequency-shift crystal oscillator and reactance tube circuit

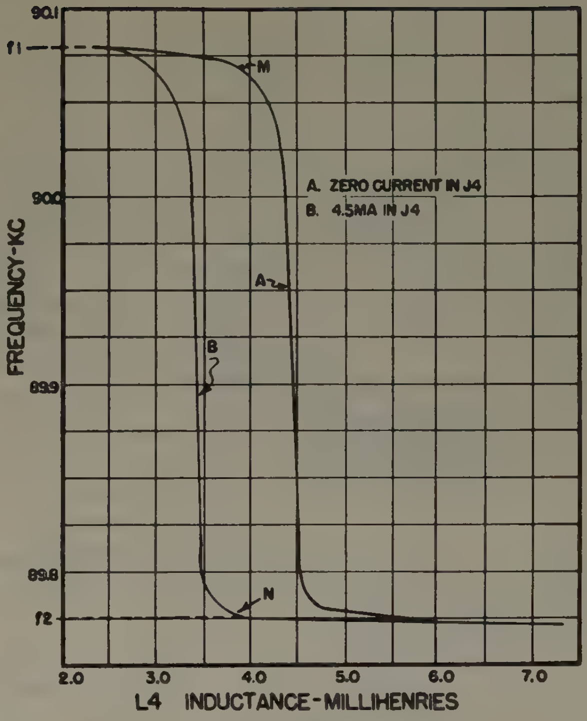

Figure 2. Crystal oscillator characteristics

In order to understand the fundamental limitations in the use of two separate oscillators, consider the conditions present at the instant of switching from one frequency to the other. The two oscillators may be in phase at the instant of switching, in which case the change in frequency will occur smoothly. On the other hand the two oscillators may be of any instantaneous phase relation from 0 to 180 degrees. If they are exactly 180 degrees out of phase at the instant of switching, the tuned circuit of the output tube suddenly will be driven by a current 180 degrees out of phase with the voltage across it. This current will reduce the voltage to 0 in a few cycles and then build up the voltage at the slightly different new frequency.

This same phenomenon will be repeated in the various receiver-tuned circuits in a very complex manner. In the case of the receiver crystal filter, because of the high Q of the crystal, this transient takes a much longer time. As a result, if the transmitter is switched at a rate equal to one-half the shift in carrier frequency, for example, the carrier voltage does not have an opportunity to build up in the receiver during one-half of the keying cycle.

It can be seen that the two oscillators will be out of phase Δf times a second where Δf is the difference between the two oscillator frequencies. If the keying rate a equals Δf divided by any integer, the keying may occur out of phase every time. It was found in practice that the receiver failed to function for $\Delta f/a$ of any integer less than

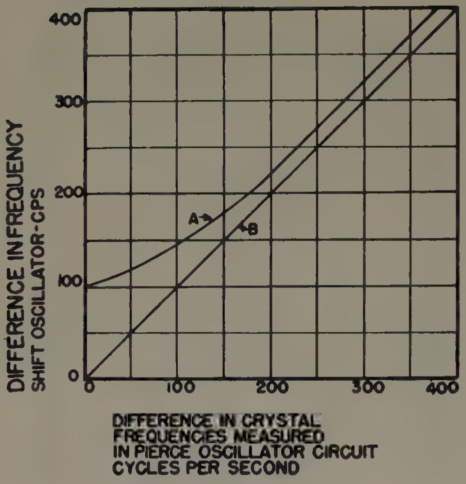

Figure 3. Plot of frequency shift versus difference in crystal frequency for double-crystal oscillator

about 10. When the ratio $\Delta f/a$ was nearly an integer, the system would operate first and then fail at the expected beat rate between Δf and a.

A search was begun for a circuit which would shift smoothly from one frequency to another and still have the stability of a crystal oscillator at the two frequencies. A number of circuits were investigated using one and two crystals and finally the circuit of Figure 1 was worked out.[10] It can be seen that the part to the left of the dotted line *A-A* is similar to a standard Hartley oscillator, except that the return circuit to the grid is through a crystal network consisting of *Y1A* and *Y1B*.

If the phase shift versus frequency through the crystal network is plotted and compared to the phase shift versus inductance characteristic of the tuned circuit consisting of *L4* and *C13*, it will be found that the crystal characteristic varies much more rapidly with frequency. For conditions of oscillation there must be approximately equal but opposite phase shift through these two circuits, in order to bring the oscillator grid voltage 180 degrees out of phase with the plate voltage. It can be seen, therefore, that a large change in inductance *L4* (or capacity *C13*) will cause a phase shift which can be counteracted in the crystal network by a very small shift in frequency. The crystals can be considered as providing frequency "stops" limiting the frequency shift to precisely predetermined values. The part to the right of the dotted line *A-A* is a conventional reactance tube circuit across the major portion of inductance *L4*.

The reactance of capacitor *C18* is large compared to resistor *R8* and, therefore, a voltage is applied to the grid of *V3* which lags the voltage across *L4* by nearly 90 degrees. The radio-frequency component of the current through *V3*, therefore, leads the voltage across *L4*, and *V3* acts as additional capacity thereby lowering the resonant frequency of the tuned circuit. A control voltage when applied to the control grid of *V3* as shown, therefore, varies the current through *V3* and thereby the resonant frequency of the tuned circuit.

The operating characteristics of this circuit are shown on Figure 2. Curve *A* shows the way in which the frequency varies with inductance *L4*. This characteristic is ideal, since the circuit first oscillates at *f1* at which point it is evident that the tuned circuit has virtually no effec on frequency. The frequency then changes rapidly bu continuously to *f2* where again the tuned circuit has no effect. It is evident that *f1* and *f2* are determined almost entirely by crystals *Y1A* and *Y1B*. Curve *B* is with reactance tube *V2* conducting a specified amount. It can be seen that this causes exactly the same change as a change in the tuned circuit since the shape of curves *A* and *B* are identical. By proper adjustment, the reactance tube can be made to vary the frequency from point *M* to point *N*.

In order to understand better the relation of the crystal frequencies to the two stable oscillator frequencies, a series of curves was taken on two pairs of crystals. One of each pair of crystals was plated or deplated in a silver bath in order to change the frequency difference between the crystals. A series of curves similar to Figure 2 was made.

The frequency shift of the double-crystal oscillator was taken as the difference between the stable frequencies *f1* and *f2*. This frequency shift is plotted in Figure 3, curve *A*, against the frequency difference of the crystals as measured in a Pierce oscillator circuit,[11] and shows a very interesting correlation between the two factors. Curve *B* is merely a 45-degree line for comparison with curve *A*.

Figure 4 is the calculated characteristic of the network formed by crystals *Y1A* and *Y1B*. The general shape of this curve is well established, but the curve is only estimated between the critical points *X*, *Y*, *Z*, and the approaches to 0 and infinite frequency. It is believed that points *X* and *Z* exist where the feedback is insufficient to sustain oscillation. The circuit performance is conceived as follows:

As the resonant frequency formed by inductance *L4* and capacitor *C13* (of Figure 1) is changed so as to produce a phase shift between voltage e_1 and the tube current, the frequency will move (say toward point *X*) until a correcting phase shift is obtained in the crystal network. The feedback magnitude curve shows a lower value of e_3 occurr

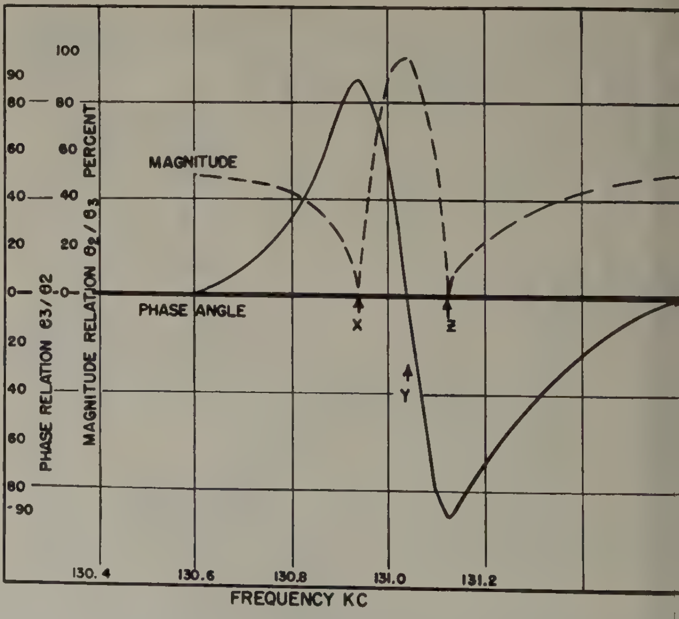

Figure 4. Magnitude and phase-angle characteristics of 2-crystal network used in frequency-shift crystal oscillator

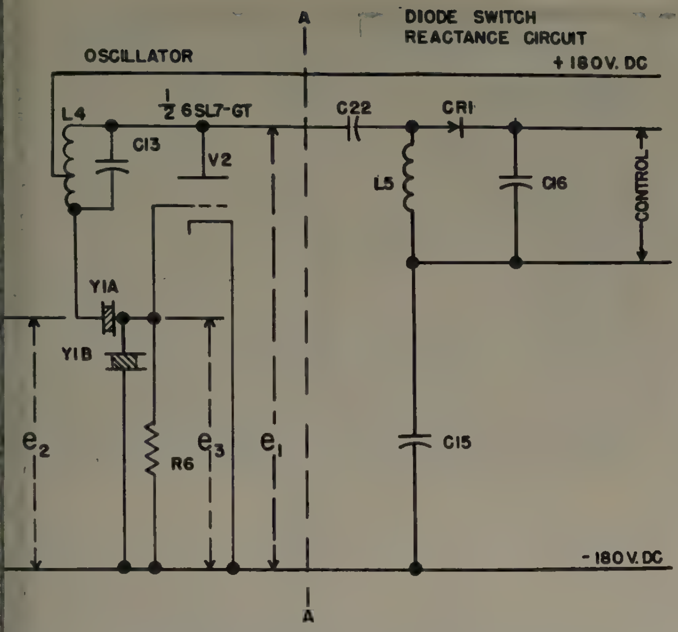

Figure 5. Simplified diagram of latest frequency-shift transmitter using diode switching reactance circuit

and this also will have an effect upon determining the frequency of oscillation. Apparently both the phase and magnitude characteristics of the crystal network limit the shift in frequency to a stable value as shown in Figure 2.

A shift in frequency toward point Z is again limited by the same factors. If the resonant frequency of the inductance capacitance (L-C) circuit is varied a large amount above or below the crystal frequency, the circuit suddenly will jump to a noncrystal-controlled frequency where apparently the crystal network acts merely as a capacitor divider with no phase shift. Operation in the neighborhood of crystal resonance is perfectly stable, however, with no tendency for the operation to be indeterminate.

Figure 5 shows a later frequency-shift oscillator circuit in which the reactance tube circuit has been replaced by a diode-switching circuit.[12–14] In this circuit a fixed capacitor is switched across the tuned circuit for a variable portion of each radio-frequency cycle in accordance with the amount of control voltage acting as diode bias. It can be shown that this is equivalent to the variable reactive current drawn by the reactance tube used previously. Use of this circuit eliminated one tube from the transmitter and eliminated the need for a careful adjustment of the control voltage.

CRYSTAL DISCRIMINATOR

The circuit shown in Figure *6A* was developed to produce a typical discriminator action but on a greatly magnified frequency scale. In other words, a circuit was needed which would detect very small changes in frequency. Because of the very small shift in frequency, stability was definitely a problem and the use of highly stable quartz crystals was indicated.

The impedance characteristic of a quartz crystal is shown in Figure *6B* and in greater detail in the appendix. At frequencies away from crystal resonance, the crystal looks like a small capacitor and current i_1 equals current i_2. As a result, voltage $E2$ is essentially zero. At the point where the crystal goes through series resonance, the current i_2 exceeds current i_1 and a net negative output voltage results. At a slightly higher frequency, the crystal goes through parallel resonance, and the current i_1 exceeds current i_2 so a net positive voltage results. The resulting characteristic curve is shown in Figure *6C*. This has all the characteristics of a conventional discriminator except that the separation between positive and negative voltage peaks is a small percentage, which would be unobtainable with *L-C* circuits.

It was found that this circuit could be aligned rather easily by balancing capacitor *C1* for low output at frequencies above and below the operating point. Frequencies spaced 0.5 per cent above and below the center frequencies were found to be best for this adjustment. It was also found that inductance *L2* could be adjusted to make the positive and negative peaks equal. An increase in *L2* towards the point where it was resonant with capacitor *C1* causes an increase in the positive peak since this resonance effects the current i_1.

This discriminator has the advantage that the frequencies corresponding to peak positive and negative output are determined almost entirely by the crystal, and therefore it has the stability of the crystal itself. In other previously known crystal discriminators this was not true, and in fact they consisted of a conventional *L-C* discriminator with a

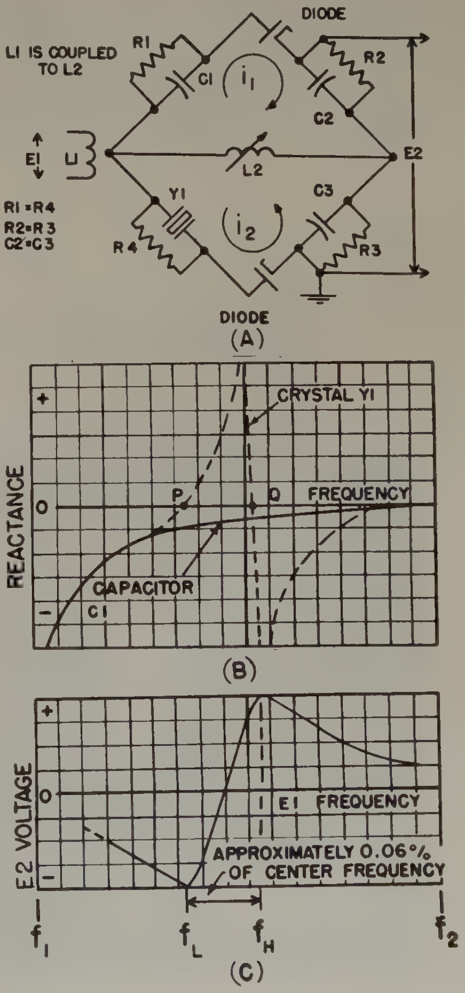

Figure 6. Crystal discriminator. A—Circuit diagram B—Crystal characteristic C—Discriminator circuit characteristic

crystal added so as to produce a characteristic which was a composite of the desired crystal response plus very undesirable additional responses much wider in frequency.

This first discriminator circuit was tried in an application which differed in certain respects from that for which the circuit was originally designed. In this application, interfering signals could not always be eliminated by tuned circuits and it was hoped that the selectivity of the discriminator itself could be used to eliminate the effects of these frequencies when slightly above or below the desired signal.

A curve of d-c output of the original circuit versus input frequency is shown on Figure 6*C*. It would be expected that if equal voltages at f_2 and f_L were imposed on the circuit that a positive output would result which would hardly be affected by the presence of f_2. Actually it was found that for this to be true, the rectifiers must produce an output voltage proportional to the sum of f_L and f_2. As f_L and f_2 are mixed together they appear as shown on Figure 7*A*.

For the d-c output to fulfill the foregoing requirement, it is necessary for the time constant of the equivalent d-c circuit to be long enough to hold the charge from time t_1 to t_2. In other words, the time constant must be long compared to the frequency difference between f_L and f_2 (divided into one). On Figure 7*B* the original discriminator is shown, and *C* and *D* show the equivalent radio-frequency and d-c circuits, respectively.

While it is possible to make the time constants of *R1-C1* and *R2-C2* large enough, half the direct voltage appears across *R3* and *R4*. Since *R3* and *R4* have the very small capacity of the crystal and its equivalent capacity *C3* across them, it is not practical to make these time constants sufficiently large. As a result, the original discriminator does not have the expected off-frequency selectivity

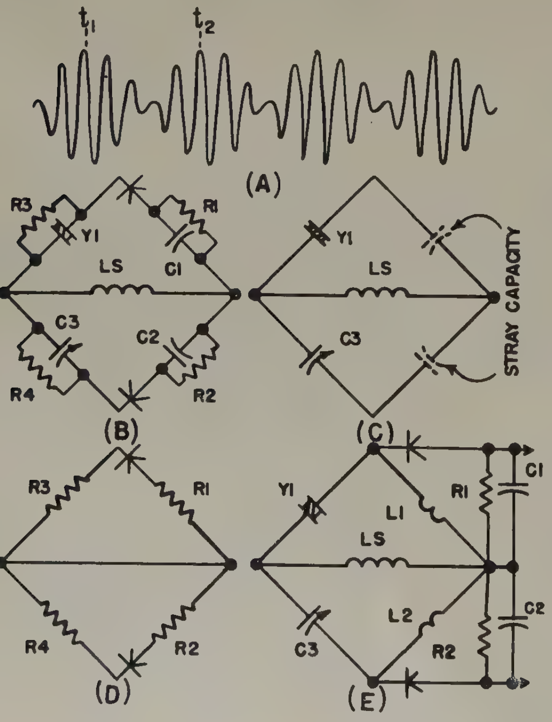

Figure 7. Diagrams illustrating crystal discriminator operation

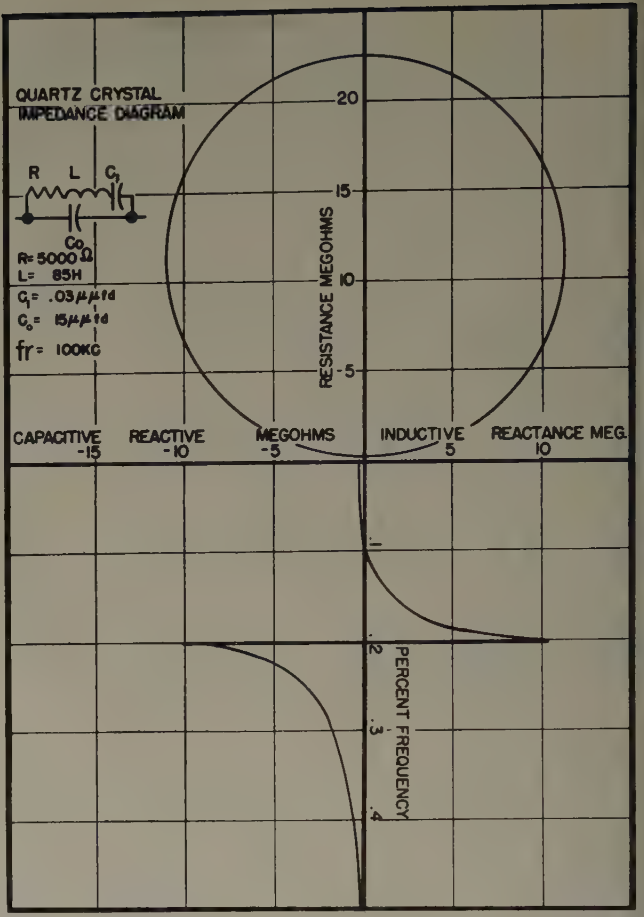

Figure 8. Impedance diagram of quartz crystal in 2-dimensiona form

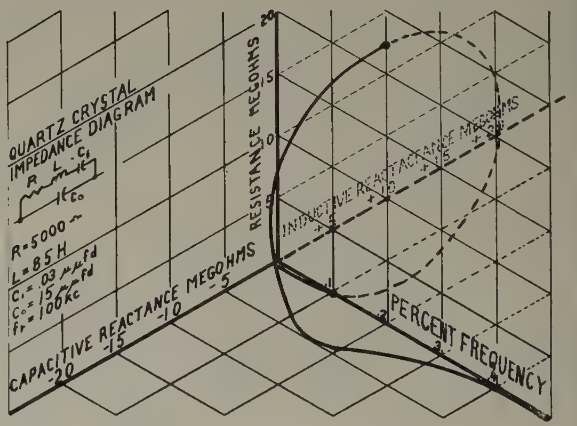

Figure 9. Impedance diagram of quartz crystal in isometric forn

As an alternate step, it is obvious that *R3* and *R4* ca return to the right side rather than the left side of *LS* wit no effect on the equivalent d-c circuit. If it is impossibl to have the time constants associated with *R3* and *R* sufficiently large, the undesirable effects can be eliminate by making these resistances very low so that only a smal part of the direct voltage appears across them. This incidentally, also would result in an improved efficiency c the circuit. At carrier frequencies, however, *R3* and *R* should be capacities approximately equal to *C3*, or abou

0 micromicrofarads. All one must have, therefore, is a 0-micromicrofarad capacitor with zero d-c resistance. n approach to this is not as difficult as one might expect, owever. An inductance of low d-c resistance and esonant at a frequency somewhat below the lowest freuency to which the discriminator must tune will fulfill his requirement. Actually for a receiver which must une from 70 to 200 kc, inductances resonant at 50 kc ere used with good results. The resultant circuit is hown in Figure 7*E*.

This circuit has been tested for the effect of interfering equencies at 131 kc and was found to be superior to the riginal circuit in rejecting signals a few kilocycles above nd below 131 kc.

Appendix

PROBABLY OF MOST VALUE in working with crystal circuits is a thorough understanding of the way in which the impedance aries with frequency in the immediate neighborhood of resonance. n order to study this, one must draw the equivalent electric circuit nd determine the values of the various elements. The equivalent ircuit is the schematic shown in Figures 8 and 9.

The crystal exhibits a parallel and series resonance very close ogether in frequency. A useful relation is

$${}_1=\frac{2C_0\Delta\omega}{\omega}$$

here $\Delta\omega$ is the frequency spacing of these resonances and ω is the rystal frequency.

Typical values for a 100-kc crystal are $\Delta\omega=0.1$ per cent and ${}_0=15$ micromicrofarads. From this, C_1 immediately can be found equal 0.03 micromicrofarad and L is the inductance necessary to esonate 0.03 micromicrofarad at 100 kc, or 85 henrys.

Using the foregoing values, an accurate impedance plot was alculated, and the impedance diagram is shown in 2-dimensional orm in Figure 8. The lower part is the familiar reactance-frequency iagram. The upper part is a circle as seen on the complex impedance plane. These are really two views of a 3-dimensional curve which can be visualized as though Figure 8 were removed and folded on the reactance axis.

In Figure 9 an isometric plot of the same curve is shown. The impedance at any frequency, of course, is a vector from the frequency axis to the curve. The rather unconventional lettering on Figure 8 and Figure 9 was done so the two could be compared in all details to enable a better visualization of the curve.

This diagram has been explained in a little more detail than is usually available in the textbooks in the hopes that it might aid engineers in future work with crystal circuits. Careful comparison of the two figures should permit complete visualization of the curve.

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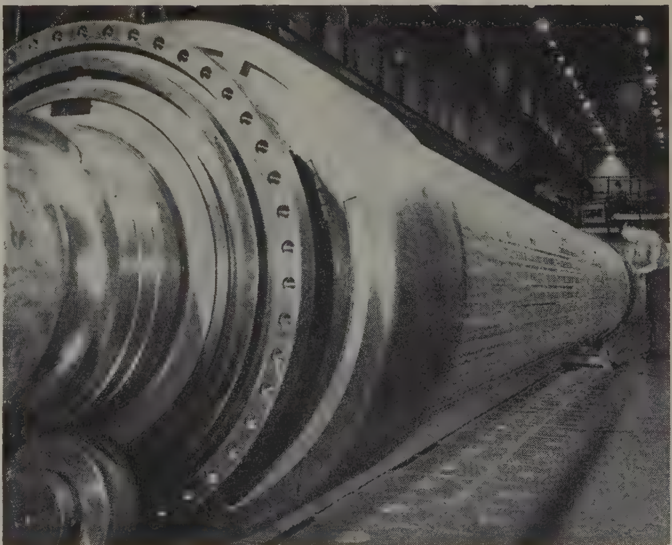
Turbine-Generator to Operate on Highest Steam Temperature

Production of a turbine which will operate with the ighest steam temperature ever used in a turbine-generator nit was announced recently by the General Electric urbine Division. The new turbine, operating at an itial temperature of 1,100 degrees Fahrenheit, will be sed in a turbine-generator for the Kearny generating ation of the Public Service Electric and Gas Company, ewark, N. J. Among special design features of the earny machine is the use in the inner shells of stainless eel, which is necessary because of the high temperature. his unit is one of the first 3,600-rpm machines generating lectricity at 20,000 volts. Another unique feature is hat the boiler for the turbine will employ coal, oil, or gas, r a combination of all three as fuel.



Shown at right is the generator rotor which will be urned by the turbine. It is 32 feet long and weighs 00,000 pounds.

A Passive Compensator for Voltage Flicker

P. A. CARTWRIGHT
MEMBER AIEE

A simple transformer device described here as a line-drop compensator greatly reduces voltage fluctuations produced at one load by the switching of another associated load. It applies to both steady-state and transient disturbances.

MOTOR STARTING on secondary distribution systems frequently results in undesirable lamp flicker. A drop of 2 volts will produce a perceptible lamp flicker for a 120-volt 100-watt tungsten filament lamp.[1] There are numerous cases of rural customers located at the end of long primary extensions where motor starting and running produce objectionable reductions in the utilization voltages.

Lighting systems are not the only type of loading which may be subjected to voltage surges due to switching of other parallel loads. Many sensitive experimental laboratory circuits require constant or nearly constant voltage sources with a minimum of waveform distortion. An elevator operating from a secondary system supplying other loads can cause an often repeated and annoying voltage disturbance, as was the case in the circumstances that are described in this article.

The electrical engineering laboratories of the University of Minnesota are supplied from a 3-phase transformer bank of single-phase units. The building freight elevator motor is also supplied from this same bank. The effect of the elevator operation on the laboratory supply system was recently made more pronounced by a change in the building service from a 120/240-volt delta bank to a 120/208-volt Y-connected bank. The laboratory utilization voltages are 240 volt 3 phase, 120 volt 3 phase, and 120/240 volt single phase. The change-over of several campus buildings to a 120/208-volt service necessitated an additional transformer bank between the main vault and the electrical engineering laboratory distribution panel. The diagram of Figure 1 shows the present arrangemen used to feed the electrical engineering laboratory system.

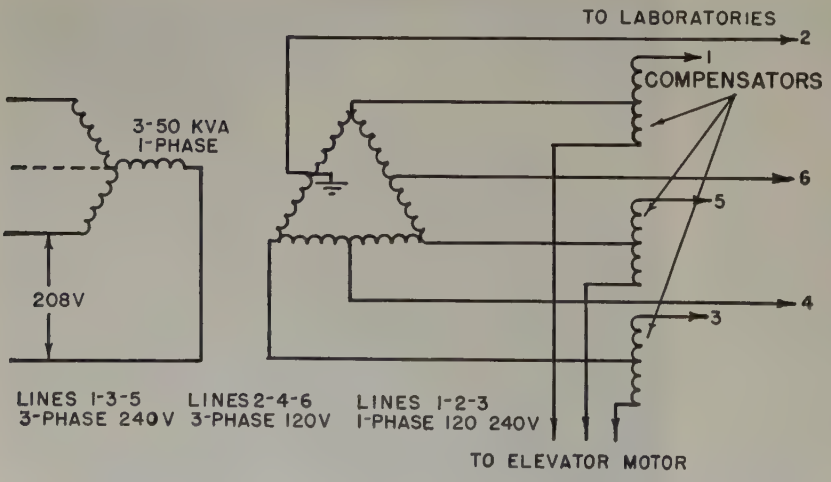


Figure 1. Supply circuits for electrical engineering department laboratories

PREVIOUS DEVELOPMENTS

A WIDE VARIETY of voltage regulators and stabilizer have been devised for application on distributio systems. Step-voltage regulators are in common use o primary distribution systems, but they are of little value fo local voltage regulation where the disturbing element i a motor or any other parallel load. Application of suc a regulator at the load location to control the secondar voltage is costly and because of its relatively slow respons it cannot eliminate the transient voltage drop.

Synchronous - synchronou motor-generator sets are sometimes employed for laboratory service and may provid an excellent stable voltag source. They are bulky an expensive, however, and unless an extremely stable source is required are not economically justified.

The electronic voltage regulators now commonly employed are generally quite satisfactory for the supply o relatively small loads. For applications requiring th elimination of local switching surges, but where some long time voltage drift can be tolerated, the electronic regulato may not be economically feasible. This would be particularly true where loads as large as 50 kva are involved.

Another method of voltage regulation inserts a fixe value of voltage boost in a circuit at the time of load switching. This is somewhat inflexible and does not always allo for variation in the magnitude of the load being switche

Automatic voltage compensators hav been devised for resistance welding control.[2] Most of these devices do not actually regulate the line voltage but ar used in conjunction with phase-controlle welding circuits to advance or retard th firing voltages of ignitron-type tubes.

A static voltage regulator utilizing serie and parallel combinations of capacitanc

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The author wishes to express his appreciation to Dr. H. Hartig, Professor and Head of the Department of Ele trical Engineering, for suggesting the use of the device d scribed in this article and for his helpful comments duri the design and installation of the units.

and inductance has found some application on single-phase circuits and on 3-phase 4-wire Y systems.[3] This type of regulator employs a nonlinear reactor and limits voltage changes to ±0.5 per cent for a 30-per-cent variation in line voltage. It has an efficiency of about 90 per cent in a 1-kva size and produces considerable and undesirable waveform distortion at light loads.

An automatic voltage regulator utilizing ferroresonance has been patented by P. H. Craig.[4] This device does not regulate the whole voltage but uses a small booster transformer and regulates only a small part of the total voltage.

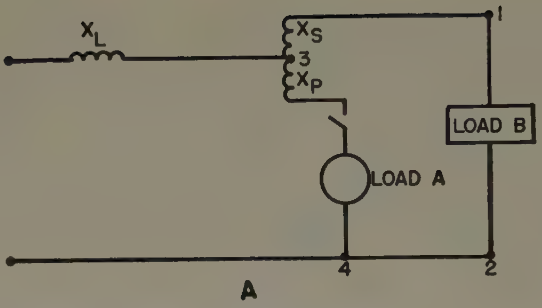
Series capacitors can be used to improve steady-state voltage stability but transients are not suppressed and they present some protection problems. The possibility of self-excitation and resulting instability of induction motors fed from lines containing series capacitors also must be considered in such applications.[5]

All of the afore-mentioned voltage regulators produce a more or less constant load voltage as the load itself is varied. In certain applications it may be allowable to permit a drop in the voltage supply to the disturbing load and to compensate only for the voltage reduction of the associated load.

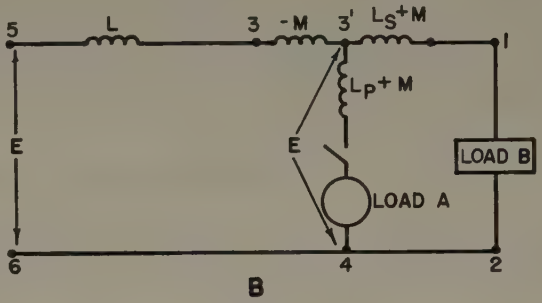
For combined lighting and motor loads, or for any combination where the switching of a portion of the load causes disturbance on the remaining load, assuming that the power supply itself is steady, a voltage regulator consisting of a very simple transformer device may be used to eliminate voltage drops to the steady loads associated with switched loads.

NOMENCLATURE

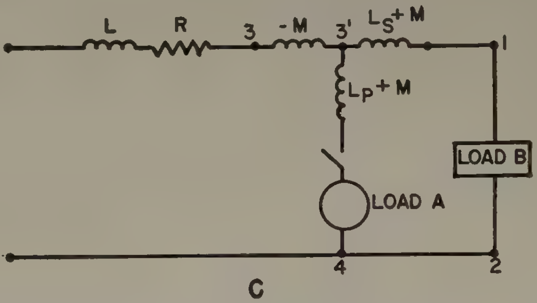
X_L = inductive reactance of distribution system
R = resistance of distribution system
X_s = inductive reactance of compensator winding in series with load B
X_p = inductive reactance of compensator winding in series with load A
X_m = mutual reactance of compensator unit
V_{12} = potential drop across load B
V_{34} = open-circuit voltage at load point
V'_{34} = voltage on lines with no compensation
$V_{3'4}$ = voltage on lines with compensation
I_{34} = current taken by load A



A—*Compensator application on a single-phase circuit*



B—*T-equivalent of a compensator applied to a circuit having inductance only*



C—*T-equivalent of a compensator applied to a circuit having resistance and inductance*

Figure 2

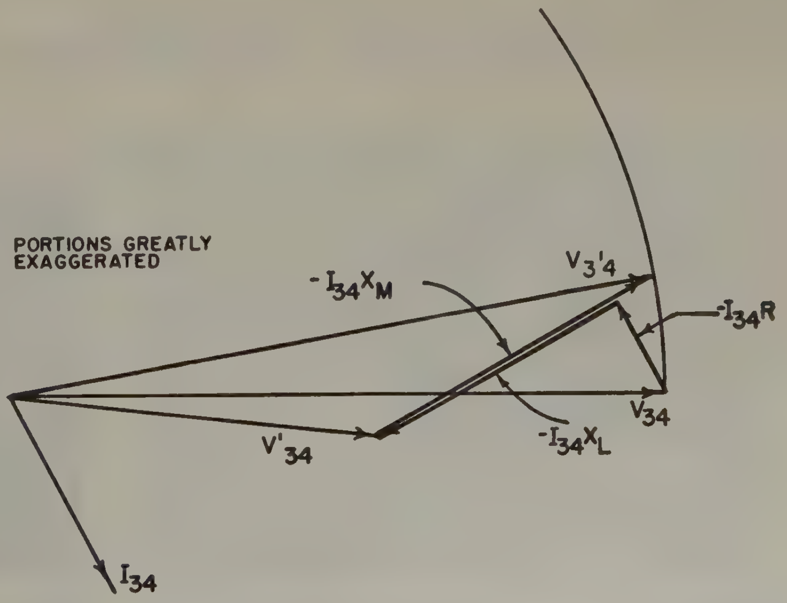


Figure 3. Current and voltage relations involved in compensator application

PASSIVE COMPENSATOR THEORY

The analysis of the inductive line-drop compensator is easily carried out by means of the T-equivalent for the transformer, Figure 2*B*, in which there is no inductive coupling between $-M$, L_s+M and L_p+M. To achieve perfect compensation for the line drop caused by L, it is necessary only that the mutual inductance $-M$ of the transformer be made equal to the line inductance L. Then $L-M=0$ and no voltage drop takes place between terminals *5–6* and *3′–4*. It is thus seen that the two loads connected to *3′–4* are connected to a bus of zero internal impedance and consequently the loads cannot interfere one with the other. If the loads are approximately of the same size, L_s and L_p appro-

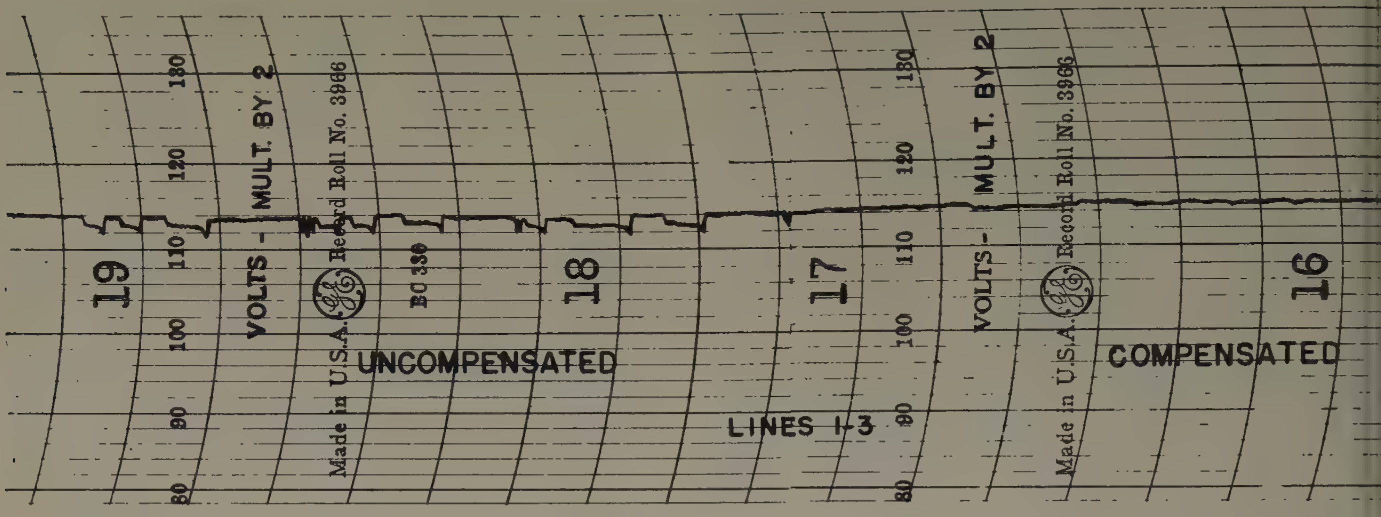


Figure 4. Voltage chart showing reduction of voltage fluctuation achieved by application of line-drop compensator

priately may be made equal, and if the coupling between the transformer coils is very close, the mutual inductance *M* will be only slightly less than $L_s = L_p$. Under these circumstances the design takes the form of a center-tapped autotransformer, with the center tap connected to the line whose reactance is to be compensated.

When the source from which power is drawn contains resistance, as well as inductive reactance, Figure 2*C*, the problem of compensating for line drop is not only more complicated but it can be achieved only in part. If the magnitude of the load voltage is to be maintained constant, some shift in phase must be allowed. However, a useful degree of compensation is possible over a fairly wide range of load and power-factor values.

The current and voltage phase relations involved in line-drop compensation are shown in Figure 3. This diagram relates only to the effects of the current taken by one load on the voltage of its associated load. The open-circuit voltage V_{34} of Figure 2*C*, is taken as the reference. When a current I_{34} is supplied to load *A*, and no compensation is made for the line drop, the voltage across points *3–4* and *1–2* becomes V'_{34}. With the same current supplied to load *A*, the use of a line-drop compensator would provide a compensating potential of valu $-I_{34}X_m$. The resultant voltage across points *3–4* now would be $V_{3'4}$. By a proper choice of X_m for given circui conditions, the magnitudes of $V_{3'4}$ and V_{34} can be made equal. It is of course possible to design a compensato unit with a value of X_m such that $V_{3'4}$ is either greater o less than V_{34} for stated values of line impedance, loac current, and power factor.

SINGLE-PHASE COMPENSATION

By way of preliminary experiment, a small compensato unit was designed for use with a 5-horsepower 110 volt single-phase repulsion-induction motor. This moto was operated from a 120-volt circuit and when placec directly across the line reduced the voltage from 120 volts to 110 volts during the starting period. Application o one compensator unit occupying only 32 cubic inche resulted in the reduction of the voltage fluctuation to less than 1 volt.

APPLICATION TO A 3-PHASE SYSTEM

The problem dealt with in this article was brough into focus by a disturbance to certain constant loads

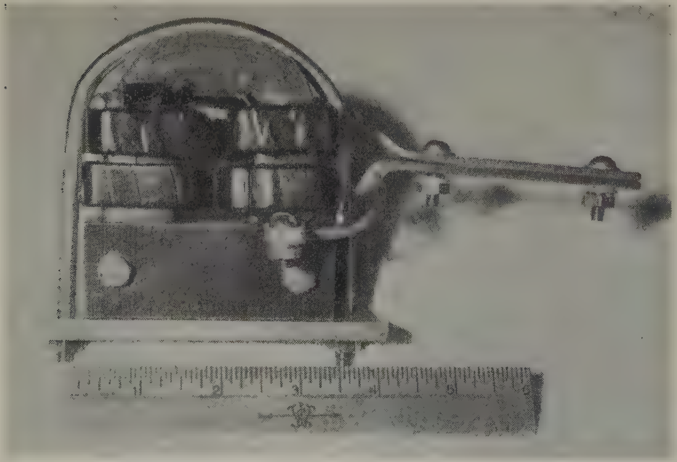


Figure 5. Compensator unit designed for use with a 22-horsepower 220-volt induction motor

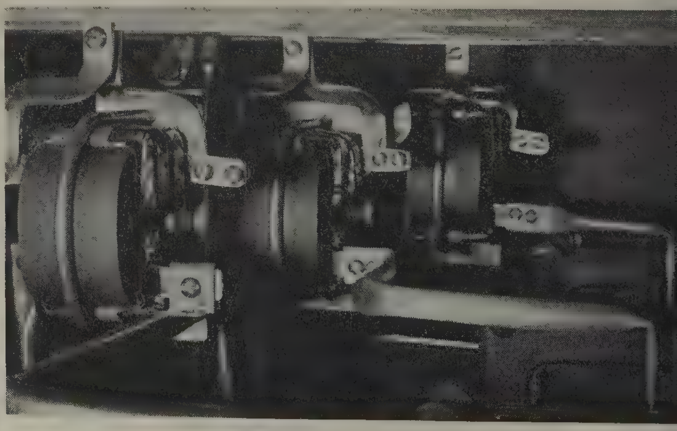


Figure 6. An installation of line-drop compensators on a 3-phas system

very sensitive to voltage changes. This disturbance was caused by a 3-phase elevator motor. The motor is a 22-horsepower 220-volt wound-rotor machine which has an operating current of approximately 60 amperes at a power factor of 60 per cent.

Let us consider this special circuit and associated loads. Referring to Figure 1, the source of the utilization voltages was a transformer bank of three single-phase 50-kva transformers, and the disturbing load was the elevator motor. The voltage-sensitive loads which were to be protected against voltage fluctuations were the various research and experimental laboratories supplied from lines *1–3–5*. The use of passive line-drop compensators such as described in this article proved to be a satisfactory solution to this particular problem of voltage fluctuation.

DESIGN AND APPLICATION

IN ORDER TO CARRY out the design of the compensators for this installation on something other than a cut-and-try basis, the supply system resistance and reactance per phase were determined and measurements were made to determine the starting current, running current, and power factor of the elevator motor. The design took the form of a center-tapped unit and the assumption was made that $X_p=X_s=X_m$. The required value of X_m was calculated to be 0.05 ohm, which can be shown to give good compensation during the starting period as well as during the running period of the elevator motor. The voltage chart shown in Figure 4 illustrates how effective these compensators are in reducing voltage fluctuations.

In the design of the unit some balance between magnetic circuit length, cross section, and saturation must be obtained. An exciting current of 110 amperes during the motor-starting period dictates the use of an air gap, the alternative being a magnetic circuit of disproportionate length. The air gap allows a very convenient means of adjustment of the compensators for operation with various types of loads after permanent installation.

A single unit is shown in Figure 5, and the final installation in Figure 6. The average length of the magnetic circuit for each core is 9 inches and the cross-sectional area 1.5 inches. An air gap of 0.016 inch gave very good operating results for the particular power source and motor involved. The coils were wound of copper strap and the windings divided between the two core legs. The over-all dimensions of each unit are 4 by 4 by 4 inches, exclusive of the bus connection, and each weighs $5^{1}/_{2}$ pounds.

CONCLUSIONS

VOLTAGE FLUCTUATIONS produced at one load by the switching of another associated load can be greatly reduced by the use of a simple transformer device herein described as a line-drop compensator. For supply lines whose impedances are principally inductive with relatively small resistive components, near-perfect line-drop compensation can be achieved. The compensation applies not only to steady-state, but also transient disturbances. Where the line resistance is not negligible, good steady-state compensation is still possible over a wide range of load-current and power-factor values.

One of the most attractive features of this type of compensation is the simplicity, compactness, and low cost of the unit. It may be expected that little maintenance will be required on this device since it is simply a low-voltage autotransformer.

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Physics Experiments to Be Televised for Cornell Students

Cornell University students will get some of their basic physics from the television screen beginning this fall. Plans to televise experiments in the freshman and sophomore physics courses were announced recently by Dr. Lloyd P. Smith, chairman of the Department of Physics.

The main lecture room has been outfitted for the project, in which the Radio Corporation of America (RCA) is co-operating. Experiments will be televised from the instructor's desk to viewing screens visible from all corners of the room.

In some cases the equipment will permit demonstrations impossible by ordinary methods. Generally, the innovation is expected to give students a better view of the experiments and instructors more opportunity to explain them.

For example, the television setup will make it easier to show "Brownian movement," the jittering dance of tiny particles suspended in a fluid. The phenomenon is invisible to the naked eye.

Ordinarily, students would wait their turns at microscopes. Now, with the television camera trained into one microscope, the image will be magnified on the screens and visible to everyone.

The department plans to use the television method to explain such other physical phenomena as light interference, surface tension, and the behavior of high-energy particles in a cloud chamber.

A midget television camera, developed by RCA Laboratories Division for industrial and related uses, is the key unit in the installation. RCA has loaned the camera and a monitor for the project. The university has provided two 21-inch viewers.

The installation is a "closed circuit," with coaxial cable linking the camera and viewing screens.

INSTITUTE ACTIVITIES

1953 Winter General Meeting to Offer 70 Technical Sessions and Conferences

Seventy technical sessions and conferences are already planned for the 1953 Winter General Meeting to be held January 19–23 at the Hotel Statler, New York, N. Y. As the 1952 meeting exceeded in size and attendance by 20 per cent the meeting which was held in 1951, so this year's meeting is expected to exceed the previous figures by a substantial margin.

TECHNICAL SESSIONS

As this issue goes to press, the following technical committees of the Institute have requested time and space for technical sessions and conferences: Special Communication Applications, Communication Switching Systems, Wire Communication Systems, Radio Communication Systems, and Television and Aural Broadcasting Systems in the Communications Division.

In the Power Division the committees on Carrier Current, Insulated Conductors, Power Generation, Protective Devices, Relays, Rotating Machinery, Switchgear, Transformers, and Transmission and Distribution are planning more than 20 technical sessions and conferences.

In the Science and Electronics Division, sessions have been requested by the committees on Electronic Power Converters, Magnetic Amplifiers, Electrical Techniques in Medicine and Biology, Electronics, Metallic Rectifiers, Computing Devices, Instruments and Measurements, and Nucleonics.

Technical sessions are also being organized by the committees on Domestic and Commercial Applications, Land Transportation, and Production and Application of Light in the General Applications Division.

The Industry Division, one of the five in the Institute, will have technical sessions and conferences sponsored by the committees on Electric Welding, Feedback Control Systems, Industrial Control, and General Industry Application.

In addition, in the Professional Division the committees on Education, Safety, and Management are each planning one technical session.

INSPECTION TRIPS

The Inspection Trips Committee expects to schedule some unusually interesting trips this year. The ever-popular Radio City Music Hall will again be included, and the committee is endeavoring to make arrangements for visits to the new liner *United States*, the United Nations General Assembly Building, now nearing completion, the Du Mont television plant, and several other local plants or facilities which should offer a wide variety of choice to visiting members.

SOCIAL ACTIVITIES

On Thursday, January 22, at 7:00 p.m., the dinner-dance will be held in the Grand Ballroom of the Hotel Statler. It is not too early now to plan for a table of ten. Music and general arrangements will be similar to those which proved so successful last winter. Dress will be formal. Write the Dinner-Dance Committee at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., for reservations.

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held at the Hotel Commodore on Tuesday evening, January 20. Reservations should be sent to the Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., at an early date.

Theater tickets will be provided as in the past years and arrangements this year should provide even greater satisfaction to those out-of-town members wishing to see the hit shows where tickets are normally difficult to obtain at legitimate prices. However, the committee feels it is inadvisable to give a specific listing of the shows that will be playing during the meeting at this time. A complete listing of shows is scheduled for the December issue of *Electrical Engineering*, and it is requested that all inquiries be deferred until that time.

Tickets to all available radio broadcasts and television shows also will be provided as in the past, to those members interested, at the time and place of registration for the meeting.

The Ladies' Entertainment Committee,

Future AIEE Meetings

Middle Eastern District Meeting
Commodore Perry Hotel, Toledo, Ohio
October 28–30, 1952
(*Final date for submitting papers—closed*)

AIEE Conference on Textiles
North Carolina State College, Raleigh, N. C.
November 6–7, 1952

AIEE Special Technical Conference on Electrically Operated Recording and Controlling Instruments
Benjamin Franklin Hotel, Philadelphia, Pa.
November 17–18, 1952
(*Final date for submitting papers—closed*)

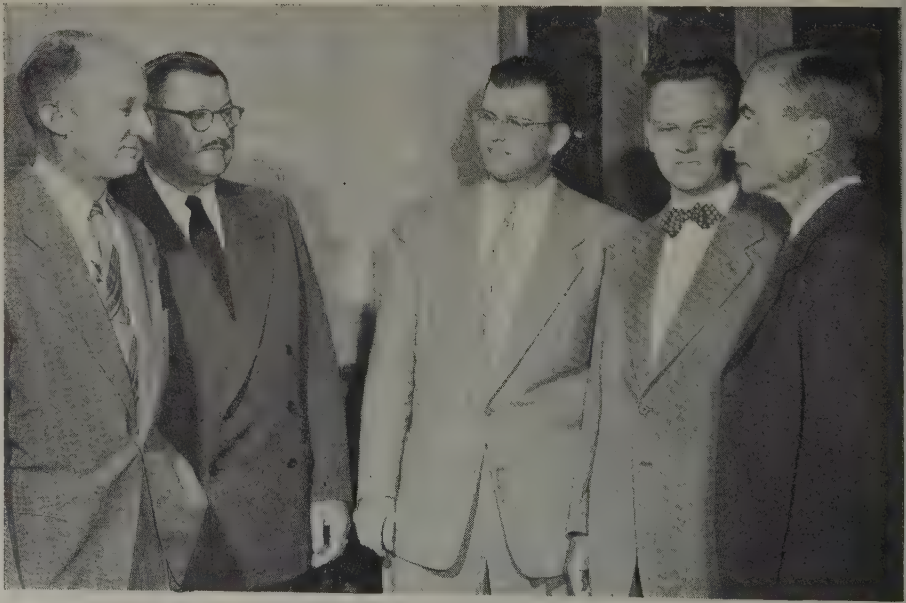
Conference on Electronic Instrumentation and Nucleonics in Medicine
Hotel New Yorker, New York, N. Y.
November 24–25, 1952

Joint AIEE-IRE-ACM Conference on Electronic Computers
Park Sheraton Hotel, New York, N. Y.
December 10–12, 1952

AIEE-IRE-NBS Conference on High-Frequency Measurements
Statler Hotel, Washington, D. C.
January 14–16, 1953

Winter General Meeting
Statler Hotel, New York, N. Y.
January 19–23, 1953
(*Final date for submitting papers—closed*)

AIEE, IRE Presidents at Albuquerque Meeting



Engineers representing the AIEE and the Institute of Radio Engineers (IRE) were guests at a recent meeting in Albuquerque, N. Mex., sponsored by the IRE New Mexico Section. Shown here, left to right, are: Don Bliss, president of the local Council of Technical and Engineering Societies; H. C. Biggs, Chairman, AIEE Northern New Mexico Section; C. W. Carnahan, Chairman, IRE New Mexico Section; IRE President D. B. Sinclair; and AIEE President D. A. Quarles

under the chairmanship of Mrs. E. S. Banghart, is planning a program of unusual interest for the ladies. On Monday, January 19, there will be the usual "Get-Acquainted" Tea at the Ladies' Headquarters in the Statler Hotel.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent as soon as possible, directly to the hotel of choice, and to only one hotel. AIEE should be mentioned in the request and a copy sent to W. G. Vieth, Chairman, Hotel Accommodations Committee, Western Union Telegraph Company, 60 Hudson Street, New York 13, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 18, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels on the list.

Hotel rooms have been reserved at the following:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 5.00 to $10.00
Double room, double bed	8.00 to 12.50
Double room, twin beds	9.00 to 17.00
Studio type	12.00 to 18.00
Parlor Suites	22.00 to 40.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 5.50 to $ 7.00
Double room, double bed	8.00 to 9.50
Double room, twin beds	9.00 to 11.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 5.00 to $ 9.00
Double room, double bed	8.00 to 13.00
Double room, twin beds	9.00 to 13.00

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 5.50 to $ 8.00
Double room, double bed	8.50 to 12.50
Double room, twin beds	9.50 to 14.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 5.00 to $ 7.00
Double room, double bed	8.00 to 10.00
Double room, twin beds	8.50 to 11.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	10.00 to 12.50
Double room, twin beds	11.50 to 14.50

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 7.50 to $10.50
Double room, double bed	13.00 to 16.00
Double room, twin beds	14.00 to 18.00

Rates are subject to 5 per cent New York City hotel room tax.

WINTER GENERAL MEETING COMMITTEE

Members of the 1953 Winter General Meeting Committee are: C. T. Hatcher, Chairman; A. J. Cooper, Vice-Chairman; J. J. Anderson, Secretary; W. J. Barrett, Budget Co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, Chairman, Committee on Technical Operations; G. T. Minasian, Publicity; J. A. Parrott, General Session; J. G. Derse, Dinner-Dance; D. E. Sullivan, Inspection Trips; C. F. Bolles, Smoker; J. G. Aldworth, Theater—Radio Television; W. G. Vieth, Hotel Accommodations; H. E. Martin, Registration and Checkup; Mrs. E. S. Banghart, Ladies' Entertainment; R. T. Weil, Monitors; J. B. Harris, Jr., Philadelphia Representative.

Electronic Instrumentation Conference Scheduled for New York, November 24–25

Problems involved in electronic instrumentation and in the rapidly growing nuclear medical applications fields will be the subject of some 18 technical papers to be presented at the fifth annual AIEE Conference on Electronic Instrumentation and Nucleonics in Medicine to be held at the New Yorker Hotel, New York, N. Y., November 24–25, 1952. This meeting will bring together prominent scientists and engineers in the nuclear and electronic fields to exchange ideas and discuss mutual problems concerned in the application of their respective specialties in the medical field.

This will be the fifth gathering of this type to be held in New York. As in former years, the conference will concern itself largely with the development, design, and application of instruments intended to facilitate medical research and everyday use of these instruments by physicians or medical technicians.

For the convenience of those attending, the meeting will be arranged so that during the first day, the papers will cover "Electronic Instrumentation in Medicine." Methods of measurement, analysis of data obtained, and a number of novel electronic instruments and accessories, important in the medical field, will be discussed. "Nucleonics in Medicine" will be the subject of papers presented on the second day of the conference. Isotope measuring techniques, the use of nuclear instruments, and effects of radiation are among the subjects which will receive attention.

A block of rooms has been reserved at the New Yorker Hotel for those participating in the conference. Write directly to the hotel for reservations.

Although publication of a conference report is not contemplated, abstracts of the papers will be a part of the printed program which will be distributed at the conference sessions.

Program

Conference on Electronic Instrumentation and Nucleonics in Medicine

Monday, November 24

Electronic Instrumentation in Medicine

9:30 a.m.

Heating of Fat-Muscle Layers by Electromagnetic and Ultrasonic Diathermy. *H. P. Schwan, E. L. Carstensen, K. Li,* Graduate School of Medicine and Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia

The Elements of Electrocardiographic Theory. *Ernest Frank,* Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia

Evaluation of Factors Affecting Accuracy in Oscillographic Recordings. *Arthur Miller,* Sanborn Company, Cambridge, Mass.

The Technique of Recording Blood Pressures With Intravascular Miniature Manometers. *O. H. Gauer,* M.D., Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio

2:00 p.m.

A Photomultiplier Tube Signal Converter for Low-Level Wide-Band Applications. *D. A. Kohl,* University of Minnesota, Minneapolis

An Oscillator Electrometer. *T. A. Rich, J. E. Bigelow,* General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

Improved Instrumentation for Spectroscopic Analysis of Isotope Mixtures. *H. J. Morowitz, H. P. Broida,* National Bureau of Standards, Washington, D. C.

A Low-Range Null-Current Recorder for Ionization Currents. *W. R. Clark, R. E. Watson,* Leeds and Northrup Company, Philadelphia, Pa.

Tuesday, November 25

Nucleonics in Medicine

9:30 a.m.

Chairman: G. Failla, Department of Radiology, Columbia University, New York, N. Y.

Trends in Detection and Measurement of Radioisotopes for Medical Purposes. *J. W. Hitch,* Advisory Field Service Branch, Isotopes Division, United States Atomic Energy Commission, Oak Ridge, Tenn.

Instrumentation Employing a Phosphor as the Primary Detector. *W. W. Schultz, R. A. Dewes,* General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

Light Collection and Transmission in Photoelectric Detection Devices. *Zane Collins, Edward Webb,* X-Ray Division, Westinghouse Electric Corporation, Baltimore, Md.

Tissue Equivalent Ionization Chambers. *H. H. Rossi,* Department of Radiology, Columbia University, New York, N. Y.

Medical Applications of Ohmart Cells. *E. L. Saenger, M.D., Ji-toong Ling, M.D.,* College of Medicine, University of Cincinnati, Cincinnati, Ohio

2:00 p.m.

Chairman: T. F. Eberhard, M.D., Department of Radiology, Jefferson Hospital, Philadelphia, Pa.

Some Biological Studies With High-Velocity Electrons. *W. D. Bellamy,* General Electric Research Laboratories, Schenectady, N. Y.

The Control and Evaluation of Air-borne Radioactive Discharge. *J. J. Fitzgerald,* Knolls Atomic Power Laboratory, General Electric Company, Schenectady, N. Y.

Techniques for Localized Irradiation and Dosimetry of the Animal Body With High-Energy Deuterons. *C. A. Tobias, H. O. Anger,* Donner Laboratory, University of California, Berkeley

Technical Aspects of the High-Energy Electron Beam Used in Therapy. *J. S. Laughlin, J. Ovadia, R. A. Harvey, M.D., L. L. Haas, M.D.,* Department of Radiology, College of Medicine, University of Illinois, Chicago

Engineering Centennial Depicts Progress in Various Branches of the Profession

Progress in all branches of the engineering profession over the past century was portrayed at the Centennial of Engineering and the Convocation of Engineers held in Chicago, Ill., September 3–13, 1952. Some 66 different societies participated in the convocation, a series of 12 symposia was conducted, and approximately 1,500 papers were presented. Total attendance was estimated at 27,000, including a foreign registration of more than 250 engineers from the free countries of Europe, Asia, and South America.

The numerous exhibits in Chicago's Museum of Science and Industry provided a great stimulus to the younger generation, while the stage dramatization, "Adam to Atom," which illustrated the theme of the Centennial, was widely acclaimed. AIEE participation was comprised of five sessions, sponsored by the five technical divisions of the Institute, embracing papers which were in the nature of historical résumés of the progress of electrical engineering in several broad fields, as well as the most recent practices. Two luncheons were held and the total registered AIEE attendance was 771 members and guests.

CENTENNIAL LUNCHEON

The features of a well-attended luncheon meeting held on September 10 were an address by the Honorable Herbert Hoover on "The Scientists' and Engineers' Promise to American Life," the presentation of the John Fritz Medal to Benjamin F. Fairless, and the presentation of the Hoover Medal to the Right Honorable C. D. Howe, Minister of Trade and Commerce and Minister of Defense Production for Canada. For the future, Mr. Hoover predicted greater advances in living and comfort than ever before known to mankind through the extended applications of knowledge, new discoveries, and new inventions. These predictions were made with the reservations that individual freedom would be maintained, that the nation would keep out of wars, and that inflation would be avoided with a reduction of taxes. The speaker received a tremendous ovation.

JOHN FRITZ MEDAL PRESENTATION

The John Fritz Medal was presented to Benjamin F. Fairless of steel fame with a citation as "champion of the American free enterprise system, for notable industrial achievement in the production of steel." On accepting the medal, Mr. Fairless presented an address, "Wanted: A Better Way," in which he spoke appreciatively of an engineering education and discussed America's need as a nation to find a better way to solve human relations problems, a way which would avoid strikes and loss of production.

The history of the medal and the reasons for the award to Mr. Fairless were given by R. E. Dougherty, Chairman of the John Fritz Medal Board of Award, who drew attention to the citation. The achievements of the medalist were described by Ralph Budd, Chairman of the Chicago Transit Authority, who pointed out the similarity in principles of Mr. Fairless and John Fritz.

THE HOOVER MEDAL PRESENTATION

The Hoover Medal, awarded by engineers to a fellow engineer for distinguished service, was presented to the Right Honorable Clarence D. Howe by Scott Turner, Chairman of the Hoover Medal Board of Award. The achievements of the medalist were given by Eugene Holman, president of the Standard Oil Company of New Jersey, who cited the medalist as an engineer of vision, energy, and decision, with the ability to get things done.

In accepting the medal, Mr. Howe paid tribute to Past-President Hoover on behalf of previous recipients of the medal, most of whom were his personal friends. In his address, Mr. Howe spoke of the scientific progress in the past 50 years and the expanded fields of engineers from the more narrow confines of technical skills and professional specialties to the broader areas concerned with management, high policy, and public affairs, and the responsibilities of the United States today in leadership in the family of free nations.

Greetings to the Convocation were extended by Martin H. Kennelly, Mayor of Chicago, who said that engineers are playing a more important part in government every year and that government needs decisions as to what is the best and the right way without any interference.

Greetings to the American Society of Civil Engineers (ASCE) on behalf of all the societies were extended by Allen S. Quartermaine, president of The Institution of Civil Engineers (ICE), which was founded in 1837. He called attention to the growth of the ASCE and the wisdom of establishing student chapters in 1920, technical divisions in 1922, and the magazine *Civil Engineering* in 1930, thus enabling men spread over a wide area to keep in touch with progress. Carlton S. Proctor, president of ASCE, responded, stating that the ASCE had patterned its course after that of the ICE, and he pointed out that the societies of Engineers Joint Council (EJC) who work together have a much deeper obligation than merely that of technology.

The Invocation was delivered by the Reverend Theodore M. Hesburgh, president of the University of Notre Dame; Major Lenox R. Lohr, president of the Centennial, was the master of ceremonies.

Electrical World photos

(Above, left) The presiding officer, T. H. David, Jr. (center) and two of the authors, Frank Thornton, Jr. (left) and R. L. Oetting, at the AIEE's General Applications Division session held during the recent Centennial of Engineering in Chicago. (Above, right) AIEE participants (left to right) S. B. Crary, L. F. Hickernell, presiding, I. W. Gross, and A. A. Johnson compare notes after the Power Division session

PRESENTATION OF FARADAY MEDAL

At the AIEE luncheon held on September 11, the Faraday Medal of the Institution of Electrical Engineers of Great Britain was presented to E. O. Lawrence, director of the Radiation Laboratory, University of California. The presentation of the medal and certificate was made by Sir John Hacking, president of the Institution of Electrical Engineers (IEE), whose address appears on pages 970–1 of this issue.

On this occasion, D. A. Quarles, AIEE President, indicated the number of engineering societies formed since the organization of the ASCE 100 years ago, and he reviewed the steps taken toward unity of the profession and the recent work in connection with the expansion of EJC in an address entitled "Organization of the Engineering Profession," which appears in full on pages 963–4 of this issue.

President Quarles presided at the luncheon, and on behalf of the Institute extended greetings to the guests present: Allen S. Quartermaine, president, ICE; Sir David Pye, president, and Ryan G. Robins, secretary, Institution of Mechanical Engineers; W. K. Brasher, secretary, IEE; AIEE Past-Presidents T. G. LeClair and F. O. McMillan; and H. H. Henline, secretary, AIEE. He congratulated Chairman F. C. Smith of the General Committee on the outstanding arrangements made for the meeting. Sir John Hacking, on behalf of the three British institutions and all the foreign institutes and associations, expressed appreciation for the kindness and hospitality received while attending the Centennial.

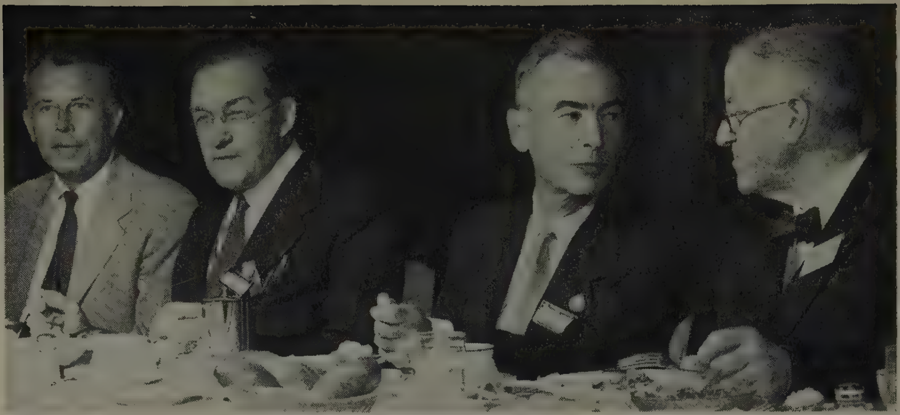
SEPTEMBER 12 LUNCHEON

The luncheon held on September 12th following the Communication Division Session and preceding the Science and Electronics Division Session was an appropriate occasion for an address, "Communication and Electronics," by M. J. Kelly, president of the Bell Telephone Laboratories, in which he reviewed the contributions of communication and electronics to our nation's strength and culture as well as the significant trends in the evolution of their technology. Complete text of the address appears on pages 965–9 of this issue.

TECHNICAL SESSIONS

Five technical sessions were held which were sponsored by each of the five divisions: General Applications, Power, Industry, Communication, and Science and Electronics. Papers were presented which summarized the progress in the art over a period of years, as well as some of the most modern trends and predictions for the future.

General Applications Division. In the session on general applications with T. H. David, Jr., presiding, four papers were presented which dealt with the fields of land transportation, air transportation, houseware appliances, and electric lighting. A cordial welcome and greetings to those in attendance were extended by F. V. Smith, General Chairman.



The Faraday Medal of the Institution of Electrical Engineers was presented at an AIEE luncheon during the Centennial of Engineering. Here, left to right, are E. O. Lawrence, the Medalist; Sir John Hacking, president, IEE; D. A. Quarles, president, AIEE; and Sir David Pye, president, Institution of Mechanical Engineers

In the first paper which was presented, "A Century of Electrical Engineering in Land Transportation," H. F. Brown of the Westinghouse Electric International Company gave a historical résumé of the various railway electrifications in this country and abroad, as well as the developments in the field of light traction, the coming of the gasoline engine, and the trend to the diesel locomotive for motive power in place of steam. For the future, he predicted a return to railway electrification with the advent of further developments in electric motive power and lower cost electric energy, which may swing the over-all economy in favor of electrification.

The second paper, "Progress in Applications of Electrical Engineering in Air Transportation," by D. E. Fritz, Chief Engineer of Jack and Heintz Precision Industries and chairman of the AIEE Committee on Air Transportation, brought out concisely the significant trend in the applications of electric equipment and systems to keep pace with the rapid improvements in airplane performance from the time of World War I to the present. For the future, he predicted that more serious consideration will be given to the design of the entire electric system and equipment as a part of the over-all airplane.

In the third paper, Frank Thornton, Jr., consulting engineer, reviewed by decades the developments in electric home appliances over the past 100 years in relation to the developments of power supply and the new materials for appliances as they became available, such as ductile tungsten and nickel chromium resistance material. The discussion which followed centered about safety considerations of grounding and electric space heating.

The fourth paper, "Electric Lighting in the First Century of Engineering," which was presented by R. L. Oetting, vice-chairman of the Committee on Production and Application of Light, brought out the historical facts regarding the men and the events that created and expanded the production and application of electric light as a science, an art, and an industry from the time of Sir Humphrey Davy.

Power Division. In the session sponsored by the Power Division, four papers were presented by well-known authors, two of whom were Edison Medalists and each of whom had been an author many times before. Brief biographical backgrounds of each were given by the presiding officer, L. F. Hickernell, chairman of the Technical Operations Committee.

The first paper by S. B. Crary, I. W. Gross, and C. F. Wagner, "Progress and Future Trends in Electric Transmission," dealt with the economic considerations and related factors such as lightning protection, symmetrical components, stability, machine analysis, calculating devices, line insulation, conductors, and various related apparatus and equipment.

The second paper, "Past Progress and Present Trends in the Art of Power Generation," by A. C. Monteith and A. A. Johnson, both of the Westinghouse Electric Corporation, was presented by Mr. Johnson. The power generating capacity of the United States during the past 7 decades has doubled every 10 or 12 years to a total to date of 80,000,000 kw. The authors brought out the various factors which, together with improved designs through the use of newer insulation, better cooling methods, and so forth, had permitted a reduction in the size of generators per kilovolt-ampere output. Notwithstanding an increase in the cost of living index from 70 in 1913 to a total of 170 in 1950, the various factors involved have reduced the price of all residential energy over the past 7 decades from an index number of 100 down to an index number of 11, or from 25 cents per kilowatt-hour to about $2^1/_2$ cents per kilowatt-hour.

The third paper dealt with the most recent practices to attain "Economical Utilization of Electric Power Equipment" and it was presented by Herman Halperin of the Commonwealth Edison Company. Studies of the following factors are required: (*a*) relation between temperature or temperature rise or both and life; (*b*) the load characteristics of the installation; and (*c*) relation between the loading characteristics and resultant temperature or temperature rise. The load capabilities inherent in the various pieces of equipment from the prime movers to the users service leads are determined. The increases in load capabilities determined by these studies for normal and, in particular, for emergency operation have effected substantial savings in investment.

In the fourth paper, "Lightning—A Hazard to Electric Systems," K. B. McEachron discussed the mechanism of the lightning stroke as determined by photographic records using the Boys-type cameras in conjunction with cathode-ray oscillographs of strokes to the Empire State Building. These data, together with data obtained by

McCann and his associates using the fulchronograph, represent practically all of the information available relating to current–time characteristics of lightning strokes measured directly in series with the stroke itself. Records were also obtained with magnetic links on transmission towers of several different lines. Dr. McEachron discussed the protection of transmission lines, the use of the overhead ground wire, the counterpoise, protection of lower voltage circuits, induced voltages due to lightning, and the application of lightning arresters.

Industry Division. In this session, a series of three papers was presented, with T. B. Montgomery presiding. From the management point of view, F. R. Benedict, Westinghouse Electric Corporation, looked toward the future in a paper entitled "Electric Power in Industry," and discussed the important factors that will govern our rate of progress such as the production problem, the production of machinery, production processes, and materials. In reference to new materials, the author discussed the lighter metals such as aluminum, magnesium, titanium, and some of the lesser known metals which may have considerable effect on product design and manufacture.

In the second paper, the rapidly expanding professional field of feedback system engineering was presented by Gordon S. Brown, Head of the Department of Electrical Engineering, Massachusetts Institute of Technology. Professor Brown discussed the state of the art, the many applications of today, and how feedback concepts have given new insight to the mechanism of the human body. He also discussed the subject as a profession and from the aspect of training men for feedback system engineering work.

The third paper entitled "Welding in the Electrical Industry," which was presented by J. Heuschkel of the Westinghouse Research Laboratories, reviewed each of the four basic processes in use: brazing, arc, resistance, and gas welding. The effects on design, the materials employed, and the engineering involved, as well as the training required and the many complex problems concerned with welding applications, were discussed.

Communication Division. In introducing the four papers presented in this session, the presiding officer, F. B. Bramhall, chairman of the Communication Division Committee, called attention to the high degree of specialization that has developed. He pointed out that all four papers attested to the fact that electrical engineering at its inception was communication. It was foreseen for the future that communication might provide such free and extensive exchange of information as to promote peace and understanding among all nations.

The first paper, "The Impress of Enterprise Upon Telegraphy's First Century," was presented by I. S. Coggeshall of the Western Union Telegraph Company. The second paper dealt with the step-by-step development of telephony in the United States and for the future predicted continued progress toward making telephone service cheaper, expansion of the television network, and faster speed of dialing across the continent. The presentation was by A. B. Clark of the Bell Telephone Laboratories, Inc. The third paper treated the historical developments of "The First 50 Years of International Radio Communication" and it was presented by Haraden Pratt, Telecommunications Advisor to the President of the United States. The fourth paper presented the "Historic Highlights in Developing the Radiobroadcasting and Television Arts" from the time of the first broadcast from Pittsburgh, Pa., on November 16, 1920, to the full-color television envisioned for the future. The presentation was by O. B. Hanson of the National Broadcasting Company.

Science and Electronics. Four papers were presented in the session sponsored by the Science and Electronics Division with Professor J. D. Ryder presiding. The first paper, "Behavior of Magnetic Materials," by R. M. Bozorth of the Bell Telephone Laboratories, was concerned with the atomic structure and its relation to the magnetic properties of the material as well as the mechanism of magnetization whereby the magnetization is changed by application of a magnetic field. These problems were illustrated with applications to ferrites and fine particle magnets. The second paper treated "The Development of Electronics and the Foundation for Industrial Application." Presented by J. E. Hobson of the Stanford Research Institute, it appears on pages 986–91 of this issue. The third paper, by F. G. Tatnall of the Baldwin-Lima-Hamilton Corporation, treated civil engineering applications of the bonded-wire strain gauge. The fourth paper, which was entitled "Computers: Past, Present, and Future," was presented by W. H. MacWilliams, Jr., of the Bell Telephone Laboratories, who is chairman of the AIEE Computing Devices Committee. The paper reviewed the computers of a century ago, the progress in this field during the past century, current computer problems, and what is in store for the future.

COMMITTEES

The members of the General Committee which made the arrangements for AIEE Participation in the Centennial of Engineering were as follows: F. V. Smith, *Chairman;* J. C. Woods, *Vice-Chairman;* R. C. Ericson, *Secretary;* H. L. Martin, *Treasurer;* M. M. Brandon; T. H. David; L. F. Hickernell; T. G. LeClair; R. D. Maxson; E. L. Michelson; T. B. Montgomery; R. R. O'Connor.

The chairmen of the other committees were as follows: *Ladies,* Mrs. T. G. LeClair, and Mrs. F. V. Smith, Cochairmen; *Hotel,* W. M. Ballenger; *Registration,* N. C. Pearcy; *Publicity,* E. R. Whitehead; *Papers,* J. F. Calvert; *Finance,* F. H. Lane.

AIEE Board of Directors Holds Regular Meeting in Phoenix

A regular meeting of the AIEE Board of Directors was held in Phoenix, Ariz., August 21, 1952.

Minutes of the meeting of the Board of Directors held on June 26, 1952, were approved.

The Board referred to the chairman of the Committee on Technical Operations suggestions that a technical committee be established to cover the electrical phases of the petroleum industry, the present coverage by a subcommittee of a technical committee being considered inadequate by some members, and that a forum or a technical conference on electrical applications in the petroleum field be held at the Fall General Meeting in New Orleans, La.

Recommendations adopted by the Board of Examiners on July 17, 1952, were reported and approved. The following actions were taken upon recommendation of the Board of Examiners: 63 applicants were transferred and two were elected to the grade of Member; 204 applicants were elected, 15 were re-elected, and one was reinstated to the grade of Associate Member; 22 applicants were elected to the grade of Affiliate; 56 Student members were enrolled.

FINANCES

Disbursements from general funds were eported by Chairman Barrett of the Finance Committee, as follows: July, $77,313.56; August, $69,960.26. Mr. Barrett reported receipts from October 1, 1951, to August 15, 1952, amounting to $930,987, or 97 per cent of the estimated income for the appropriation year. The receipts during the corresponding period last year were $807,118, or 89 per cent of the actual receipts during the appropriation year. The expenditures during the 11 months ending August 31, 1952, were $891,464, or 90.8 per cent of the estimated expenditures during the appropriation year. The corresponding figures last year were $796,939, or 92.7 per cent.

Loans for special technical conferences were reported by the chairman of the Finance Committee, as follows: Machine Tools, Albany, N. Y., October 20–31, $500; Joint AIEE-IRE-ACM Conference on Electronic Computers, New York, N. Y., December 10–12, $150.

AMENDMENTS AND RECOMMENDATIONS

Upon recommendation of the Sections Committee, it was voted that the name of the Tri-State Section be changed to Ohio Valley Section.

The Board voted that the flags of Canada, Mexico, and the United States, and an appropriate AIEE banner be sent to all general meetings for display at all general sessions, and that the present practice of making them available to District meetings upon request be continued.

The Committee on Constitution and Bylaws recommended the following amendments to the Bylaws to bring them into conformity with the decision to eliminate all ex officio memberships in committees provided for in the Bylaws and to incorporate in certain sections the recent changes in publication policy; and the Board adopted these amendments.

Section 71. Edison Medal Committee. First paragraph amended to read as follows:

> "The Edison Medal Committee shall consist of twenty-one members, including the Chairman, of whom fifteen shall be appointed by the President from the member-

ship at large and confirmed by the Board of Directors of the Institute; three to be appointed annually and to serve for a term of five years from August first of the year in which such appointments are made. Six shall be elected by the Board from its own membership, being three annually to serve from August 1 of the year in which they are elected, for a term of two years, excepting when a member so elected ceases to be a Director prior to the expiration of the two-year term, in which case his membership on the Edison Medal Committee shall terminate with his membership on the Board of Directors, and the Board shall elect a Director to serve the unexpired term."

Section 73. Headquarters Committee. Amended to read as follows:

"The Headquarters Committee shall consist of at least three members. It shall have general supervision of the arrangements, furnishings, and maintenance of the Institute headquarters, including historical relics, paintings, and works of art."

Section 77. Membership Committee. First paragraph amended to read as follows:

"The Membership Committee shall consist of one vice-chairman from each geographical District and a suitable number of other members, all to be appointed by the President. At least one member of the committee shall be a member of the Board of Directors."

Section 78. Committee on Planning and Co-ordination. First paragraph amended to read as follows:

"The Committee on Planning and Co-ordination shall consist of the chairman, who shall be appointed by the President from the Board of Directors, and such other members as the President may appoint. The committee may appoint such subcommittees, including other members of the Institute, as may be needed for specific aspects of planning."

Section 80. Publication Committee. First paragraph amended to read as follows:

"The Publication Committee shall consist of at least eight appointed members chosen to represent broadly the Institute activities in the fields of Communication, Electronics, General Applications, Industry, Power, Education, and Technical Publications. At least one member of the committee shall be a member of the Board of Directors."

Section 81. Committee on Public Relations. First paragraph amended to read as follows:

"The Committee on Public Relations shall consist of six or more appointed members, of whom at least one is a member of the Board of Directors."

Schenectady Section Officers for 1952–53

New officers of the AIEE Schenectady Section review meeting plans for the coming year. Shown from left to right are: C. C. Herskind, Vice-Chairman; R. K. Fairley, Secretary; H. C. Anderson, Chairman; and L. F. Lewis, Treasurer

Section 83. Committee on Research. Amended to read as follows:

"The Committee on Research shall consist of ten or more appointed members. At least one shall be a member of the Board of Directors. The Committee shall stimulate research of interest to the Institute; shall act on behalf of the Institute, as authorized specifically by the Board of Directors, to initiate and direct research investigations; shall co-operate, on behalf of the Institute, with departments of national and state governments in the consideration of research investigations; shall submit to the Board of Directors reports and recommendations concerning research investigations for which financial support from the Institute is sought; shall assist university staffs in selecting research projects for graduate students; and shall assist the Committee on Technical Operations, as requested, in the preparation of meetings for the discussion of problems in the field of research."

Section 84. Committee on Safety. Amended to read as follows:

"The Committee on Safety shall consist of fifteen or more members, and shall consider and investigate matters relating to the protection of persons and property against hazard due to or resultant upon the presence of electricity or the use of electrical apparatus, material, and appliances, and shall report to the Board of Directors such recommendations thereon as it shall deem desirable for action by the Institute. To this end it shall encourage and co-ordinate safety considerations by other Institute committees in their respective fields, and with the approval of the Board of Directors may arrange for co-operative relations with other bodies in the consideration of electrical hazard. At least one member of the committee shall be a member of the Board of Directors."

Section 88. Committee on Transfers. Amended to read as follows:

"The Committee on Transfers shall consist of a chairman, a vice-chairman, a secretary, and twelve additional members all appointed by the President. At least one of the fifteen shall be from the Board of Directors and ten, one from each District, shall be recommended by the Vice-Presidents or District executive committees. This committee shall encourage the Sections to establish and maintain in continuous operation their own local committees on transfers. The committee shall prepare with the approval of the Board of Examiners a guide for use by the Sections committees on transfers and other interested parties of the procedure to be followed for proposing transfers to Fellow grade. The committee shall also prepare a guide for the functioning of the Sections committees on transfers, for the purpose of encouraging and assisting eligible Affiliate and Associate Members in transfers to higher grades of membership."

Papers and Discussions

Section 100. Amended to read as follows.

"Authors and coauthors of general and technical articles which are published in *Electrical Engineering* or bimonthly publications will each be given two complimentary copies of the issue containing their contributions. Additional copies will be furnished at the special authors' price of 25 cents per copy postpaid, provided the order is placed in advance and five or more copies are shipped to one address at one time.

"Reprints of any papers published by the Institute will be furnished at nominal cost provided orders are placed in advance of publication and for quantities of 100 or more. The editorial department will quote prices upon application.

A new section reading as follows was adopted to precede Section 104:

Sec. 103a. Only original papers shall be acceptable for presentation and publication. On notification of acceptance, all papers become the property of the Institute. The publications of the Institute are copyrighted but permission to republish is usually granted provided proper credit is given to the authors and the Institute.

Section 104. Second paragraph amended to read as follows:

"An informal address, District paper, or conference

North Texas Section Inspection Trip

Members of the AIEE North Texas Section inspect the Dallas Steam Electric Station of the Dallas Power and Light Company. W. P. Eichmeyer, superintendent of the station, is second from right. The inspection trip on September 25 marked the Section's first meeting of the 1952–53 season

Miami Section Officers' Luncheon

The annual luncheon of the Advisory Board and Executive Committee of the AIEE Miami Section was held on September 18, 1952, with E. S. Lammerson, Jr., Vice-President, District 4, as guest of honor. Seated left to right, are: C. H. Summers, Chairman, Advisory Board; Otis Grannis, Miami Section Chairman; Vice-President Lammerson; R. L. Poor, Section Secretary-Treasurer. Standing, left to right: R. S. Davis, Advisory Board; E. J. Davenport, Executive Committee; Harvey Pierce, Advisory Board; William Cogburn, Section Vice-Chairman; J. B. Hiers, Jr., Advisory Board

paper not approved by the Committee on Technical Operations for presentation, but included in the program of a general or District meeting, shall not be released for publication in advance of presentation. The name of the Institute shall not be used in connection with the publication of the subject matter of such an address or paper except in *Electrical Engineering* or in news items elsewhere unless authorized by the Publication Committee."

Publications

Section 106. Amended to read as follows:

"The regular publications of the Institute shall include *Electrical Engineering* to be published monthly; *Communication and Electronics*, *Applications and Industry*, *Power Apparatus and Systems*, each to be published every two months, and the *Transactions* to be published quarterly, semiannually, or annually.

A new section reading as follows was adopted:

Sec. 106a. Each member may elect to receive one of three bimonthly publications: *Communications and Electronics*, or *Applications and Industry*, or *Power Apparatus and Systems*, in consideration of payment of dues without additional charge, and two dollars and fifty cents ($2.50) shall be deducted from the dues and applied as a subscription for the year covered by such payment. Additional bimonthly publications may be obtained by members at an annual subscription price of $2.50 each.

A new section reading as follows was adopted:

Sec. 106b. The Secretary is authorized to receive from nonmembers annual subscriptions to *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, at the rate of $5.00 each per annum, with an extra postage charge sufficient to cover the mailing costs to all countries to which the bulk rate of postage does not apply. A discount of 25 per cent from the subscription price of $5.00 will be allowed to college and public libraries upon advance subscription sent directly to Institute headquarters; publishers and subscription agencies may be allowed a discount of 15 per cent. Single copies may be obtained when available at $1.00 each.

Section 107. Amended to read as follows:

"*Electrical Engineering* may have two principal divisions:

1. For current matter and Institute news;

2. For general articles pertaining to the profession, technical papers, and other matters of an engineering character.

Section 108. Amended to read as follows:

"The *Transactions* shall contain the papers and discussions which have appeared in the bimonthly publications and such other engineering matter as may be approved for publication in *Transactions* by the Publication Committee."

Sec. 111. The *Transactions* shall be available to members and to nonmember subscribers to *Electrical Engineering* upon advance subscription at prices approved by the Board of Directors on recommendation of the Publication Committee. The Secretary is authorized to receive from nonmembers advance combination subscriptions to any two parts of the *Transactions* at an annual rate of $10.00 plus extra foreign postage or to all three parts at an annual rate of $12.00 plus extra foreign postage. The Secretary is authorized to receive from nonmembers advance subscriptions to Part 1. *Communication and Electronics*, or Part 2. *Applications and Industry*, or Part 3. *Power Apparatus and Systems*, at an annual rate of $6.00 plus extra foreign postage. Discounts from these prices may be allowed to college and public libraries (25 per cent) and to publishers and subscription agencies (15 per cent).

Back volumes of *Transactions* as available may be sold to members and nonmembers at such prices as may be authorized from time to time by the Board of Directors, and which may be secured upon application to Institute Headquarters.

OTHER ACTIONS

It was voted that graduates of degree-granting schools listed as approved in electrical engineering by The Institution of Electrical Engineers be considered as meeting the educational requirements for the grade of Associate Member, AIEE.

Upon recommendation of the Standards Committee, A. C. Muir was appointed an alternate on the Standards Council, American Standards Association, effective immediately to fill a vacancy, and also for the year 1953.

The Engineers' Council for Professional Development (ECPD) had submitted for approval names of AIEE members for appointment to ECPD committees. These names were approved by the Board, as follows:

Guidance Committee: M. S. Coover, J. H. Lampe
Education Committee: H. L. Hazen, H. N. Muller
Student Development Committee: Walter J. Seeley
Training Committee: Donald Bridgman, K. B. McEachron, Jr.
Recognition Committee: R. H. Barclay
Ethics Committee: R. W. Sorensen
Information Committee: C. S. Rich

The Board voted that the action of the Board of Directors, on June 26, establishing a new plan for Student Branch appropriations be interpreted as providing that the number of Student members in each Branch be those in good standing on November 1 plus the number of applications, accompanied by fees, on file at AIEE headquarters as of November 1; that one-half of the $1 per member portion be sent as soon as practicable after November 1, and the second half be sent by February 15; and that a student whose application and fee have been received at headquarters be eligible for prize competition.

It was voted to extend to the 1952 Pacific General Meeting Committee hearty thanks for its excellent work in planning and conducting the meeting.

It was decided to hold the next meeting of the Board of Directors in New Orleans, La., on Thursday, October 16, during the Fall General Meeting.

Other matters were discussed.

ATTENDANCE

Present at the meeting were: *President* D. A. Quarles; *Past Presidents* F. O. McMillan, T. G. LeClair; *Vice-Presidents* W. L. Cassell, W. Scott Hill, M. D. Hooven, E. S. Lammers, Jr., N. M. Lovell, F. W. Norris, J. C. Strasbourger; *Directors* Walter J. Barrett, F. R. Benedict, R. F. Danner, E. W. Davis, D. D. Ewing, A. C. Muir, N. C. Pearcy, C. S. Purnell, Elgin B. Robertson, Victor Siegfried; *Treasurer* N. S. Hibshman; *Secretary* H. H. Henline.

AIEE Textile Conference to Be Held in Raleigh

North Carolina State College at Raleigh will be host to the AIEE Textile Conference to be held November 6 and 7, 1952. Registration for the conference will take place at 11 a.m. on Thursday; the fee of $5.00 includes the cost of the luncheon on Friday.

The first session will be held on Thursday afternoon with Swaffield Cowan presiding. Following the address of welcome by Dean J. H. Lampe, the following papers will be presented:

Drive Requirements of Some Textile Machinery. *I. S. Bull, Jr.*, J. P. Stevens Company, Greensboro, S. C.

Operating Capabilities of A-C Motors. *Fred Snyder*, Westinghouse Electric Corporation, Boston, Mass.

Starting of Spinning and Roving Frames. *R. E. Parker*, General Electric Company, Schenectady, N. Y.

These papers will be followed by a panel discussion.

Activities for Thursday evening will include a cocktail hour to be held with the compliments of the manufacturers' representatives attending the conference. After cocktails, a barbecue is scheduled to which tickets will be sold at the time of registration.

J. D. McConnell of the Cone Mills Corporation, Greensboro, N. C., will preside at the morning session on Friday, November 7, which will cover:

Elevator and Control Maintenance. Monarch Elevator Company, Greensboro, N. C.

Electrical Problems and Their Remedies. *T. O. Sills*, Cannon Mills, Kannapolis, N. C.

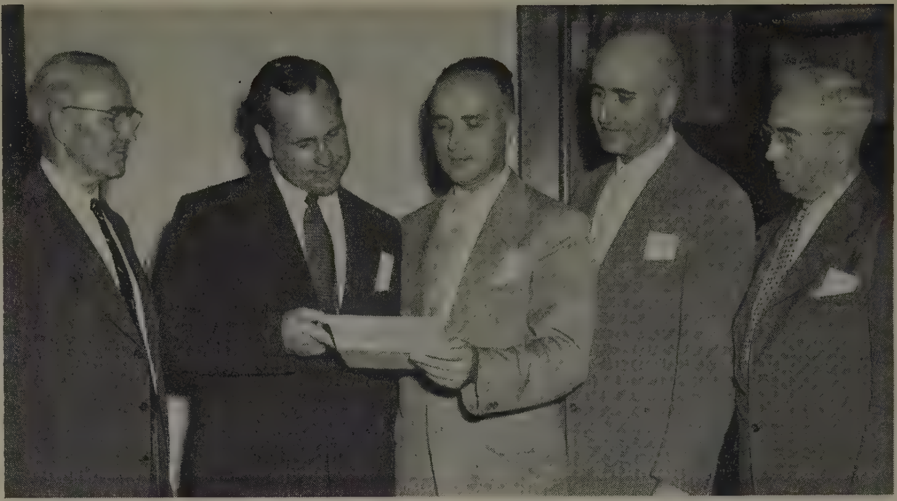
Electrical Troubles We Have Seen and What They Tell Us. A panel discussion moderated by Mr. McConnell and including, in addition to the foregoing speakers, the following: Harry Taylor, Southern Electric Service Company, Greensboro, N. C.; Harold Saline, Electric Motor and Repair Company, Raleigh, N. C.; J. C. Cummings, Bryant Electric Company, High Point, N. C.; Jack Adamson, General Electric Service Shop, Charlotte, N. C.; F. K. Shealy, Westinghouse Service Shop, Charlotte, N. C.; and a representative from the Electrical Equipment Company, Raleigh, N. C.

Friday luncheon will be held in Leazer Dining Hall on the campus with Chairman W. C. Burnett of the AIEE North Carolina Section presiding. Following lunch, the Engineering Laboratories of the college will be open for inspection with guided tours conducted by the students. Also, manufacturers' representatives will be available to discuss particular problems confronting any of the mill people.

The following Conference Committee has been appointed:

Chairman, Dr. J. H. Lampe, North Carolina State College; Dr. C. G. Brennecke, North Carolina State College; *Vice-Chairman*, Swaffield Cowan, Chairman AIEE Textile Subcommittee; J. D. McConnell, AIEE Textile Subcommittee (Program); J. T. Meador, AIEE Textile Subcommittee (Publicity); I. S. Bull, Jr., AIEE Textile Subcommittee; Dr. M. E. Campbell, North Carolina State College; W. C. Burnett, Chairman, AIEE North Carolina Section; W. W. Hammond, The Okonite Company, Charlotte, N. C.; W. W. Hanke, Southern Electric Service Company, Inc., Charlotte; David Clark, Clark Publishing Company, Charlotte; R. S. Gardner, AIEE Representative.

Lehigh Valley Section Holds Meeting



A discussion of "Ultrahigh-Frequency Television" by F. P. Barnes, Sales Manager, Broadcast Equipment, General Electric Company, Syracuse, N. Y., was the feature of a meeting of the AIEE Lehigh Valley Section in Scranton, Pa., September 12, 1952. Shown at the meeting are, left to right: D. A. Campbell, Jr., Chairman, Lehigh Valley Section; Mr. Barnes; A. W. Plonsky, Division Manager, Scranton, Pa.; J. W. Gehrke, Publicity Chairman, Lehigh Valley Section; and W. C. Seymour, Secretary-Treasurer, Lehigh Valley Section

Annual Computer Conference to Convene in New York

On December 10–12, 1952, New York City's Park Sheraton Hotel will play host to the annual Computer Conference, jointly sponsored by the AIEE, the Institute of Radio Engineers, and the Association for Computing Machinery. Following the successful pattern of the meeting held the previous year in Philadelphia, Pa., each of the 19 technical papers scheduled will be presented successively, assuring that no paper will be missed because of simultaneous presentation.

This year's conference features input and output equipment used with the many different computer systems. The extensive coverage of this subject is indicated by the following program:

December 10

Recording Techniques for Digital Coded Data. *A. Tyler*, Eastman Kodak Company

Converters for Teletype Tape to IBM-Cards. International Business Machines Corporation

Cards to Magnetic Tape Converters for UNIVAC. Remington Rand Inc.

Devices for Transporting the Recording Media. *R. L. Snyder, Jr.*, R. L. Snyder Company

Buffering Between the Input-Output and the Computer. *A. L. Leiner*, National Bureau of Standards

December 11

SEAC Input-Output System. National Bureau of Standards

UNIVAC Input-Output System. Remington Rand Inc.

Raytheon Input-Output System. Raytheon Manufacturing Company

Type-701 Input-Output Organization. *L. D. Stevens*, International Business Machines Corporation

Type-726 Magnetic-Tape Reader and Recorder. *W. S. Buslik*, International Business Machines Corporation

Magnetic-Tape Technique and Performance. *H. W. Nordyke*, International Business Machines Corporation

December 12

Survey of Analogue-to-Digital Data Converters. *H. E. Burke*, Consolidated Engineering Corporation

Survey of Mechanical-Type Printers. *J. Hosken*, A. D. Little, Inc.

Anelex Printer. *Leo Rosen*, Anderson-Nichols

Eastman Printer. *Russel Thompson*, Eastman Kodak Company

Bell Automatic Message Accounting and Ticketing Equipment. Bell Telephone Laboratories

Magnafile Department Store Recorder. W. S. MacDonald Company, Inc.

Punched Garment Tickets. Sears Roebuck and Company

Numerically Controlled Milling Tool. *W. Pease*, Massachusetts Institute of Technology

In addition, exhibits are planned by some 14 companies in the computer field.

At-the-door registration fee for the conference is $3.50. Advance registration fee is $3.00. Registration cards and hotel reservation forms may be obtained from A. C. Holt, Chairman of the Registration Committee, International Business Machines Corporation, 590 Madison Avenue, New York, N. Y.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Land Transportation (*L. W. Birch, Chairman; Jacob Stair, Jr., Vice-Chairman; G. M. Woods, Secretary*). Plans for two sessions covering two general subjects are shaping up for the coming Winter General Meeting in New York, N. Y. One session will be devoted entirely to rapid transit. Speakers from large cities where recent new installations of rapid transit have been made have accepted the responsibility of describing their operations. Boston, Mass., New York, N. Y., and Chicago, Ill., will be covered. The modernization of cars, substation and distribution equipment, and signaling for these systems will be discussed.

The second 1-subject session for the Winter General Meeting will be devoted to the operation and maintenance of diesel-electric locomotives. Authors from leading railroads as well as from industry will present these papers. Since the diesel locomotive has been in service on many railroads for a number of years, data now available will provide interesting and authentic answers to many operators who are entering the diesel field. This should be an extremely interesting session for men in the railroad field.

Power Division

Committee on Carrier Current (*C. W. Boadway, Chairman; S. C. Leyland, Vice-Chairman, East; R. H. Miller, Vice-Chairman, West; B. W. Storer, Secretary*). Future technical sessions of the Committee on Carrier Current, as discussed during the Summer General Meeting in Minneapolis, included plans for the 1952 Pacific General Meeting in Phoenix and Fall General Meeting in New Orleans. Further discussion indicated that eight additional papers were available, or were being prepared, from which a technical session could be scheduled during the Winter General Meeting in New York in January. Also discussed was the desirability of a session during the 1953 Pacific General Meeting in Vancouver, British Columbia, Canada, with West Coast personnel.

One of the papers to be presented in January will be the "Bibliography on Carrier Current," covering power-line carrier, space radio and microwave, and low-frequency control systems, during the period 1933 through 1949, which was approved for publication by the Committee on Carrier Current at this meeting.

Discussion of new business brought out the need for more active participation by operating company carrier and microwave personnel, particularly in the committee's program of measurement and evaluation of attenuation and noise characteristics. It was emphasized that there is no field where closer co-operation is needed between designer and user than in the carrier field, and although manufacturers are sending their key men to aid in the solving of the complex technical problems confronting this group, operating companies are not supporting such activities to the extent that is to be desired. Suggestions from utility managements or other interested parties on ways and means of obtaining the desired participation and responsibility by operating men in the program and meetings are earnestly invited by the executive of the Committee on Carrier Current.

Committee on Power Generation (*J. A. Brooks, Chairman; J. B. McClure, Vice-Chairman; H. R. Harris, Secretary*). The Committee on Power Generation is planning five joint sessions for the Winter General Meeting of which two will be with the Rotating Machinery Committee on Power Plant Auxiliaries, two will be with the Committee on System Engineering on System Load Control, and one will be with the Electrostatic Processes Subcommittee on Electric Precipitators. The sessions on power plant auxiliaries are a continuation of the two sessions included in the program of the Fall General Meeting in New Orleans, October 13–17.

The Subcommittee on Speed Governing is sponsoring papers for the sessions on system load control, speed governing of prime movers being an important part of this problem. In regard to electric precipitators, the committee hopes to have an interesting session from the points of view of both the equipment manufacturer and the user. The papers will treat the practical application of electrical precipitation as well as some of the theoretical aspects of this subject.

Industry Division

Committee on Electric Welding (*C. N. Clark, Chairman; E. J. Limpel, Vice-Chairman; J. F. Deffenbaugh, Secretary*). While many of the members were attending the National Metal Exposition and the Fall Meeting of the American Welding Society in Philadelphia, Pa., business sessions were held on October 21 for the Electric Welding Committee and the newly organized Subcommittee on Instrumentation for Resistance Welding.

In addition to the presentation of the subcommittee reports, plans were made for publication of 1952 conference papers, technical sessions on arc welding and instrumentation during the New York winter meetings, and consideration was given to holding another welding conference in 1954. The new Instrumentation Subcommittee has started a comprehensive study of industry needs for more information on application of various instruments to electric welding.

Committee on Feedback Control Systems (*F. E. Crever, Chairman; H. W. Cory, Vice-Chairman; L. C. Harriott, Secretary*). The Committee on Feedback Control Systems has been very active in recent years as its theories and equipment have gained further acceptance. It has two subcommittees. The Subcommittee on Terminology and Nomenclature has as its scope the preparation of proposals on standard terminology, nomenclature, and symbols for feedback control systems for acceptance by the AIEE Standards Committee and the American Standards Association. The Subcommittee on Bibliography has for its scope the compiling and preparing for publication of a bibliography of pertinent American and foreign technical literature pertaining to feedback control systems. This work is being done in co-operation with the Bibliography Subcommittee of the Committee on Industrial Control.

Plans for technical sessions at the Fall General Meeting and Middle Eastern District Meeting have been completed. All members of the committee are urged to solicit papers for succeeding meetings of the Institute.

Although there has been discussion as to whether or not the committee should be under the Industry Division, no action will be taken this year to change. Members who have taken a position in that regard are about equally divided in their opinions. Papers on the successful application of new theories or principles on feedback control systems are desired whether in the industrial field or more nearly allied to electronics and communications.

Science and Electronics Division

Committee on Electrical Techniques in Medicine and Biology (*S. Reid Warren, Jr., Chairman; A. M. Zarem, Vice-Chairman; T. H. Rogers, Secretary*). The committee is encouraged, after one full year of operation, by the evidences of widespread interest in the field of its work. Two sessions at the Summer Meeting in Minneapolis, one jointly with the Committee on Safety, were well attended and accompanied by spirited discussions.

Dr. A. M. Zarem, Committee Vice-Chairman, has stimulated interest in the West by correspondence and personal contacts, culminating in a well-received session of three papers presented at the Pacific General Meeting in Phoenix on August 22, 1952.

Major objectives now include work on the Fifth Annual Conference on Electronic Instrumentation and Nucleonics in Medicine scheduled for November 24–25, 1952 at the Hotel New Yorker, New York, N. Y.; and on sessions planned for the Winter General Meeting which is to be held in New York in January.

The committee welcomes suggestions and offers to contribute from members of AIEE and others interested in the fast-growing fields of its endeavors.

Committee on Computing Devices (*W. H. MacWilliams, Jr., Chairman; J. C. McPherson, Vice-Chairman; F. J. Maginniss, Secretary*). At a meeting of the committee in July, it was decided to recognize the expanding activity in the digital computer field by establishing several new subcommittees, on information storage devices, analogue-digital conversion, semiconductor components for computers, input-output devices, and information theory. The first two of these projected subcommittees are now being formed and the others will follow later.

A Digital Computer Comparisons Subcommittee has been formed, under the chairmanship of Professor R. E. Meagher. The purpose of this group is to establish means of comparing the effectiveness of different designs of digital computers in handling various classes of problems. This will require defining various characteristics of computer design and performance, assembling characteristics of various machines, determining the requirements of the different sorts of problems, and formulating means of comparing the abilities of computers with the demands of the problems. It is planned to publish reports of the Digital Computer Comparisons Subcommittee as *Transactions* papers.

As for the forthcoming bibliography on computing devices, most of the 1-sentence abstracts have been completed and it is being edited under the guidance of Dr. J. W. Mauchly, the new chairman of the Computer Bibliography Subcommittee. The bibliography will be published as a *Transactions* paper.

The Committee on Computing Devices is sponsoring a joint AIEE–Institute of Radio Engineers–Association for Computing Machinery conference on input-output equipment in New York on December 10–12, 1952.

AIEE Section and Student Branch Meetings—1951–1952

Table I. Section Membership, August 1952; Section Meetings During Year Ending April 30, 1952

Section	AIEE Members August 1952	Number of Meetings	Total Number of Meetings
Akron	187	9	9
Alabama	351	10	
Subsection: Mobile-Pensacola		10	20
Arizona	213	10	
Group: Technical		11	21
Arkansas	152	10	
Groups: Pine Bluff Technical		7	
Little Rock Technical		1	
Subsection: Northwest Arkansas		9	27
Arrowhead	61	9	9
Beaumont	131	10	
Subsection: Lake Charles		8	18
Boston	1,044	9	
Groups: Basic Sciences		2	
Distribution		2	
Electronics		2	
Industrial Power Application		2	
Instruments and Measurements		2	
Insulation		1	
Land Transportation		3	
Power Generation		2	
Transmission		2	
Wire Communications		3	
Subsection: New Hampshire		5	35
Canton	114	10	
Group: Management Discussion		1	11
Central Illinois	156	9	
Group: Technical		1	10
Central Indiana	365	9	9
Chicago	2,055	6	
Groups: Basic Sciences		3	
Communications		4	
Electronics		5	
Industrial		5	
Power		5	28
Cincinnati	345	11	11
Cleveland	938	10	
Groups: Basic Sciences		4	
Electrical Construction		4	
Instruments and Measurements		4	
Motors and Control		4	
Power Generation and Distribution		4	30
Columbus	190	13	
Subsection: Zanesville		12	25
Connecticut	658	10	
Group: Technical		15	25
Corpus Christi	87	5	5
Dayton	444	11	
Groups: Aeronautics		3	
Electronics		3	
Motor and Controls		2	
Power		3	
Subsection: Lima		8	
Joint Meeting: Section and Lima Subsection		1	31
Denver	487	10	
Groups: Communications and Electronics		5	
Electrical Equipment		4	
Power Systems		2	
Subsections: Black Hills		5	
Casper (Wyo.)		3	
Joint Meetings: Power Systems and Electric Equipment Groups		2	31
East Tennessee	353	19	
Group: Knoxville Technical		4	23
El Paso	130	17	
Subsection: Pecos Valley		1	18
Erie	160	17	
Subsection: Ridgway		13	30
Fort Wayne	188	8	8
Georgia	331	10	
Subsection: Savannah		7	17
Houston	333	11	
Groups: Communication		3	
Industrial Applications		1	
Subsection: Freeport		6	21
Illinois Valley	93	11	
Group: Technical		8	19
Iowa	243	14	
Subsection: Quad-Cities		8	22
Ithaca	277	8	
Group: Discussion		1	
Subsection: Binghamton Area		8	
Binghamton Area Discussion Group		4	21
Jacksonville	76	4	
Subsection: Tampa		3	7
Kansas City	382	16	
Group: Technical Discussion		14	30
Lehigh Valley	449	10	
Group: Technical		1	11
Los Angeles	1,921	9	
Groups: Aircraft		6	
Electronics		6	
Power		5	
Subsection: Boulder City		8	34
Louisville	195	8	8
Lynn	370	22	22
Madison	104	9	9
Mansfield	101	8	8
Maryland	884	7	
Groups: Communications		2	
Industrial Electronics		4	
Power		3	
Subsections: Eastern Shore		8	
Lancaster-York		6	
Joint Meeting: Section and Lancaster-York Subsection		1	31
Memphis	116	10	
Subsection: Nashville		1	11
Mexico	205	9	9
Miami	150	12	12
Michigan	1,045	7	
Groups: Electronics		3	
Industrial Power		3	
Instruments and Measurements		3	
Round Table		6	
Welding		3	
Subsection: West Michigan		7	32
Milwaukee	938	8	
Groups: Basic Science		3	
Electric Machinery		3	
Power Application and Control		4	
Transmission and Distribution		2	
Subsections: Fox River Valley		9	
Racine-Kenosha		9	
Joint Meetings: Electronics and Basic Science Groups		4	
Electric Machinery and Transmission and Distribution Groups		1	43
Minnesota	422	9	
Group: Aeronautical		2	
Subsection: Red River Valley		7	18
Mississippi	85	7	7
Montana	126	5	
Group: Technical Study		7	
Subsections: Billings		10	
Great Falls		8	30
Montreal	421	14	
Group: Discussion		1	
Subsection: St. Maurice Valley		6	21
Nashville	73	7	7
Nebraska	188	10	
Group: Relay Technical		8	18
New Orleans	268	7	
Group: Technical		3	
Subsections: Baton Rouge		8	
Jackson		2	
Joint Meeting: Section and Baton Rouge Subsection and Louisiana State University Branch		1	21
New York	5,826	1	
Groups: Basic Science		3	
Communication		9	
Illumination		5	
Power and Industrial		12	
Transportation		4	
Subsections: Hudson Valley		6	
New Jersey		9	
Joint Meeting: Communication and Basic Science Groups		1	50
Niagara Frontier	292	12	12
Niagara International	154	14	14
North Carolina	328	2	
Subsections: Charlotte		10	
Mid-State		3	15
Northeastern Michigan	136	13	13
Northern New Mexico	167	6	6
North Texas	586	10	
Groups: Aircraft Electrical		1	
Distribution Practices		2	
Subsections: Central Texas		9	
Fort Worth		5	
West Central Texas		9	
Joint Meeting: Section and Forth Worth Subsection		1	37
Oak Ridge	106	10	10
Ohio Valley	75	14	14
Oklahoma City	229	9	
Groups: Ardmore Technical Discussion		3	
Electronics		4	
Industrial and Commercial Practices		3	
Power Systems		4	23
Ottawa	74	12	12
Panhandle Plains	183	14	14
Philadelphia	1,819	12	
Groups: Aircraft Electric Devices		1	
Basic Sciences		3	
Communications		5	
Electronics		3	
Industrial Practices		3	
Instruments and Measurements		2	
Power Systems		3	
Subsection: Wilmington		9	
Joint Inspection Trip: Section and Wilmington Subsection		1	42
Pittsburgh	1,302	8	
Groups: Communications		3	
Industry		1	
Power Generation		1	
Transmission and Distribution		2	
Subsections: Centre County		7	
Johnstown		9	31
Pittsfield	343	18	18
Portland	594	18	18

Table I (continued). Section Membership and Meetings

Section	AIEE Members August 1952	Number of Meetings	Total Number of Meetings
Providence	165	8	8
Richland	135	12	12
Rochester	238	21	21
Rock River Valley	98	9	9
Sacramento	110	9	9
St. Louis	727	8	
Groups: Electronics		8	
Industrial Apparatus		6	
Industrial Power Practices		10	32
San Diego	218	11	
Group: Technical		2	13
San Francisco	1,526	34	
Subsections: Eureka		4	
Fresno		7	
Hawaii		12	
San Jose		8	
Shasta		6	
Joint Inspection Trip: Section and San Jose Subsection		1	72
Schenectady	1,102	17	
Subsection: Adirondack		3	20
Seattle	680	9	
Groups: Aircraft		5	
Basic Sciences		3	
Electronics and Communications		1	
Power		7	
Transportation		3	
Subsection: Tacoma		8	
Joint Meetings: Section and Tacoma Subsection		2	
Basic Sciences and Power Groups		1	39
Sharon	233	11	
Subsection: Youngstown		1	12
Shreveport	138	10	10
South Bend	149	12	12
South Carolina	186	1	
Subsection: Columbia		11	12
South Texas	143	9	
Subsection: Corpus Christi		4	13
Spokane	165	8	8
Springfield	114	10	
Group: Technical		3	13
Syracuse	365	7	
Subsection: St. Lawrence International		6	
Joint Meeting: Section and St. Lawrence International Subsection		1	14
Tampa	132	1	1
Toledo	171	10	
Groups: Motors and Control		3	
Power Systems		2	15
Toronto	813	13	
Groups: Communications		3	
Discussion		10	
Subsection: Hamilton		10	
Joint Meetings: Section and Discussion Group		1	
Section and Communications Group		1	
Section and Hamilton Subsection		1	
Communications and Hamilton Subsection		1	40
Tulsa	204	10	
Group: Technical		7	17
Utah	171	10	
Subsection: Boise		1	11
Vancouver	255	11	
Group: Discussion		8	
Subsection: Vancouver Island		9	28
Virginia	236	4	
Subsections: Hampton Roads		9	
Richmond		5	18
Virginia Mountain	110	5	5
Washington	1,140	9	
Groups: Basic Science		1	
Communications - Instrumentation-Electronics		2	
Nucleonics		1	
Power		3	16
West Virginia	124	9	9
Wichita	141	13	13
Worcester	107	8	8
	40,915		1,762

Total Sections, 94
Total technical groups, 102
Total Subsections, 54

Table II. Branch Meetings Held During Year Ending April 30, 1952

Branch	Number of Meetings
*Akron, University of	9
Alabama Polytechnic Institute	12
Alabama, University of	9
*Alberta, University of	5
*Arizona, University of	24
*Arkansas, University of	15
*British Columbia, University of	20
Brooklyn, Polytechnic Institute of	
Day Division	12
Evening Division	5
*Brown, University	5
*Bucknell University	3
California Institute of Technology	5
*California, University of	13
*Carnegie Institute of Technology	24
Case Institute of Technology	3
Catholic University of America	4
Cincinnati, University of	9
Clarkson College of Technology	6
Clemson A & M College	—
Colorado A & M College	10
*Colorado, University of	15
*Columbia University	1
*Connecticut, University of	12
*Cooper Union	8
*Cornell University	8
*Delaware, University of	5
*Denver, University of	7
*Detroit, University of	6
*Drexel Institute of Technology	8
Duke University	4
Fenn College	7
*Florida, University of	10
George Washington University	12
Georgia Institute of Technology	—
Howard University	10
Idaho, University of	17
Illinois Institute of Technology	13
*Illinois, University of	8
*Chicago Division	11
*Iowa State College	8
Iowa, University of	14
*Johns Hopkins University	12
Kansas State College	5
*Kansas, University of	9
Kentucky, University of	9
*Lafayette College	12
Lehigh University	8

Table II (continued). Branch Meetings

Branch	Number of Meetings
Louisiana Polytechnic Institute	13
*Loisiana, University of	9
Louisville, Eniversity of	10
*Maine, University of	4
*Manhattan College	7
*Marquette University	7
*Maryland, University of	6
*Massachusetts Institute of Technology	8
Massachusetts, University of	10
*Michigan College of Mining and Technology	10
*Michigan State College	2
*Michigan, University of	7
Milwaukee School of Engineering	11
*Minnesota, University of	7
Mississippi State College	8
*Missouri School of Mines and Metallurgy	11
*Missouri, University of	—
*Montana State College	10
*Nebraska, University of	10
Nevada, University of	12
Newark College of Engineering	3
*New Hampshire, University of	6
*New Mexico College of A & M Arts	12
*New Mexico, University of	3
*New York, College of the City of	11
*New York University	
Day Division	13
Evening Division	7
*North Carolina State College	12
North Dakota State College	7
*North Dakota, University of	7
*Northeastern University	29
*Northwestern University	3
Norwich University	2
*Notre Dame, University of	10
Ohio Northern University	11
*Ohio State University	9
*Ohio University	6
*Oklahoma A & M College	10
Oklahoma, University of	7
*Oregon State College	15
*Pennsylvania State College	14
*Pennsylvania, University of	6
Pittsburgh, University of	13
*Pratt Institute	3
*Princeton University	10
Puerto Rico, University of	1
Purdue University	7
*Rensselaer Polytechnic Institute	4
*Rhode Island, University of	6
Rice Institute	7
Rose Polytechnic Institute	10
*Rutgers University	12
Santa Clara, University of	3
*South Carolina, University of	15
South Dakota School of Mines and Technology	9
South Dakota State College	9
*Southern California, University of	—
*Southern Methodist University	12
*Stanford University	11
*Stevens Institute of Technology	1
Swarthmore College	4
*Syracuse University	6
Tennessee, University of	5
*Texas, A & M College of	5
*Texas Technological College	6
*Texas, University of	12
Texas Western College Sub-Branch	7
*Toledo, University of	7
Toronto, University of	14
*Tufts College	9
*Tulane University	6
Union College	8
United States Naval Academy	—
*Utah, University of	22
Vanderbilt University	11
Vermont, University of	5
*Villanova College	16
Virginia Military Institute	7
*Virginia Polytechnic Institute	20
*Virginia, University of	7
Washington, State College of	11
*Washington, University of	12
Washington University	5
*Wayne University	8
*West Virginia University	6
Wisconsin, University of	—
*Worcester Polytechnic Institute	6
*Wyoming, University of	12
*Yale University	10
	1,177

Total Branches, 132
* Joint AIEE-IRE Branches (81).

AIEE PERSONALITIES.....

A. J. Williams, Jr. (AM '27, M '45), associate director of research, Leeds and Northrup Company, Philadelphia, Pa., received a John Price Wetherill Medal from The Franklin Institute for his invention of the "Speedomax" self-balancing recorder, on October 15, 1952. Mr. Williams was born in Media, Pa., in 1903 and was graduated from Swarthmore College in 1924. He worked for 3 years as transformer engineer at the Bell Telephone Laboratories in New York, N. Y., and in 1927 he joined Leeds and Northrup Company as a test and research engineer, being promoted to the post of chief of the electrical division of the research department in 1934. In 1948 he was appointed assistant to the director of research and in 1951 was made associate director of research. He is a member of Sigma Xi, the American Physical Society, and the Institute of Radio Engineers. He has served the AIEE on the following committees: Research (1936–40); Standards (1949–50); Feedback Control Systems (1949–52); and as Liaison Representative on Standards (1951–52).

E. C. D. Molina (M '22, F '51, Member for Life), special lecturer in mathematics, Newark (N. J.) College of Engineering, and **H. B. Taylor** (M '26), consulting engineer, Haverford, Pa., received Elliott Cresson Medals from The Franklin Institute of the State of Pennsylvania on October 15, 1952. The medals are awarded for discovery or original research adding to the sum of human knowledge, and leading and practical utilizations of discovery. Mr. Molina, a native of New York City, joined the Western Electric Company in 1898 and then transferred to the engineering department of the American Telephone and Telegraph Company in Boston, Mass. Transferred to New York in 1907, he continued with American Telephone and Telegraph and later with the Bell Telephone Laboratories as switching theory engineer. His contributions in translating system pulses contributed largely to the development of the dial telephone of today. Following his retirement from the Bell Laboratories in 1942, he joined the staff of the Columbia University War Research Division and in 1945 went to Newark College of Engineering. He is a fellow of the Royal Economic Society and a member of the American Mathematical Society, the American Astronomical Society, American Statistical Association, and other professional groups. He received the honorary degree of doctor of science from Newark College in June 1952. **H. B. Taylor** was born in Philadelphia, Pa., in 1882 and was graduated from the Towne Scientific School, University of Pennsylvania, in 1905. He started with I. P. Morris Company, subsidiary of William Cramp and Sons Ship and Engine Building Company of Philadelphia, in 1905, serving as draftsman, designer, and engineer in the manufacture of high-power hydraulic machinery, and progressed to assistant hydraulic engineer in 1907, hydraulic engineer in charge in 1911. He became assistant to the president, Cramp Company, in 1915. He was vice-president and director of the Cramp Shipbuilding Company from 1940 to 1949, when he became a consulting engineer. He is a member of The American Society of Mechanical Engineers, the American Society of Civil Engineers, Society of Naval Architects and Marine Engineers, and others.

E. C. D. Molina

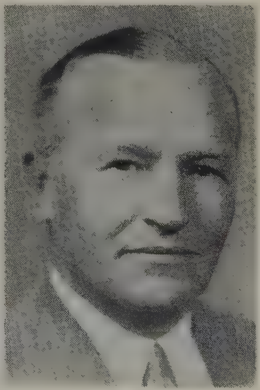
S. C. Leyland (AM '40, F '51), manager, relay engineering, Westinghouse Electric Corporation, Newark, N. J., has been named manager of engineering for the Westinghouse Meter Division. A native of Fall River, Mass., Mr. Leyland received his degree in electrical engineering from Worcester Polytechnic Institute in 1924. He joined Westinghouse at East Pittsburgh, Pa., in 1925, and held various engineering posts there until his transfer to the Meter Division in 1931 as design engineer for indicating instruments. From 1941 until his new appointment, he was manager of the relay engineering section. He has served on the following AIEE committees: Protective Devices (1941–45), Relays (1947–52), Carrier Current (1947–52), Radio Communications Systems (1950–52), and Liaison Representative on Standards (1951–52).

F. C. Lindvall (AM '26, F '43), chairman of the Division of Engineering, California Institute of Technology, Pasadena, has been named a member of a 5-man team to visit industrial laboratories in six Italian cities under the sponsorship of the Organization for European Economic Co-operation and the Mutual Security Agency. Before leaving for Italy, Professor Lindvall will present a paper on research training before the Engineering College Administrative Council of the American Society for Engineering Education. He has served the AIEE on the following committees: Electric Machinery (1936–38), Electrophysics, Basic Sciences (1936–47), Transportation, Land Transportation (1938–43), and Education (1951–52).

C. A. Culver (F '22), senior physicist, Southwest Research Institute and dean of professional development, Essar Research Center, San Antonio, Tex., has been appointed chairman of Trinity University Department of Physics, San Antonio. Dr. Culver received a bachelor of science degree from Carleton College in 1902 and the doctor of philosophy degree from the University of Pennsylvania in 1907. After teaching in high school, he became professor of physics at Beloit (Wis.) College, where he taught for 13 years. He was chief high-frequency engineer for Canadian Radio Corporation from 1920 to 1923, professor of physics at Carleton College, Northfield, Minn., from 1923 to 1946, and professor at Park College, Parkville, Mo., from 1947 to 1951. Dr. Culver holds various patents relating to communications engineering. A specialist in industrial and architectural acoustics, he has published four books. He is president of the Southwest Research Institute branch of The Scientific Research Society of America, a fellow of the Institute of Radio Engineers, Acoustical Society of America, American Association for the Advancement of Science, Sigma Xi, and Phi Beta Kappa.

H. D. Moreland (AM '35, F '48), sales manager, X-Ray and Electronics Division, Westinghouse Electric Corporation, Baltimore, Md., has been named manager of the X-Ray Division. A native of Philomath, Oreg., Mr. Moreland received an electrical engineering degree from Oregon State College in 1930 and a master of science degree 2 years later. He joined the Westinghouse X-Ray Division in 1933 at Portland, Oreg. He was transferred to San Francisco, Calif., in 1935 and returned to Portland as X-Ray Division manager in 1938. In 1942 Mr. Moreland was named manager of X-ray products for the agency sales department, East Pittsburgh, Pa., and in 1944 became manager of X-ray engineering. He rejoined the X-Ray Division in 1946, and became sales manager of the X-Ray and Electronics Division in 1948. He has served the AIEE on the following committees: Applications of Electricity to Therapeutics, Therapeutics (1944–51, Chairman 1949–51); Standards (1949–50); Technical Program (1949–50); Science and Electronics Co-ordinating, Science and Electronics Division Committee (1949–51); and Electrical Techniques in Medicine and Biology (1951–52).

W. R. Herod (AM '20), president of the International General Electric Company, New York, N. Y., has been elected a vice-president of the General Electric Company.



H. B. Taylor

He will continue as president of the International General Electric Company. He joined the General Electric Company in Schenectady, N. Y., in 1919. A native of Indianapolis, Ind., he was graduated from Yale University, Sheffield Scientific School, in 1918. After serving as special assistant in the construction engineering department of General Electric, Mr. Herod transferred to International General Electric in 1929. From 1934 to 1937 he was assistant to the managing director of Associated Electrical Industries in London, England, and in 1937 he returned to New York as vice-president of International General Electric. Called to active service with the Army Air Force in 1942 as a lieutenant colonel, he was promoted to a colonelcy and served with the Air Technical Service Command at Wright Field, Dayton, Ohio, and at Detroit, Mich. He was elected executive vice-president of International General Electric on his return to the company in July 1945 and became president later that year. In January 1951, Mr. Herod was appointed Co-ordinator of Defense Production, North Atlantic Treaty Organization, and served for a year in that capacity with the rank of minister.

E. A. Loew (AM '03, F '36, Member for Life), professor of electrical engineering, University of Washington, Seattle, retired in June 1952. He received the degree of bachelor of science in electrical engineering from the University of Wisconsin in 1906 and the electrical engineer degree from the same university in 1922. He became an instructor in electrical engineering at the University of Washington in 1909 and was promoted to the rank of full professor in 1923 and to Dean of the College of Engineering in 1935. He held these positions until 1948 when he retired from administrative work, continuing as professor of electrical engineering and Dean Emeritus. He has been active in the American Society for Engineering Education and the Engineers' Council for Professional Development. He has been an active member of the AIEE, serving as secretary of the Seattle Section (1913–15) and as chairman (1925–26). He was a member of the following Institute committees: Education (1916–19, 1929–31, 1940–41, 1945–49); Student Branches (1916–17, 1936–38, 1939–41); and Power Transmission and Distribution (1926–27, 1936–39). He is the author of numerous technical articles and two books.

Fraser Jeffrey (AM '11, F '24, Member for Life), assistant to chief electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., retired July 31, 1952. He received his electrical engineering degree from the Toronto Technical School, Toronto, Ontario, Canada. After graduation, he was employed as a draftsman at the Polson Works, Toronto. Later he became an engineer with the Bullock Electric Manufacturing Company, Cincinnati, Ohio, a subsidiary of Allis-Chalmers. Mr. Jeffrey was transferred in 1908 to the parent plant in Milwaukee, Wis., where he has been instrumental in the design of electric motors and the development of special electric equipment. He is a past president of the Engineers' Society of Milwaukee. Mr. Jeffrey has served the AIEE on the following committees: Iron and Steel Industry (1920–21); Industrial and Domestic Power, General Power Application (1920–22, 1930–34); Transportation, Land Transportation (1938–46); and Power Generation (1942–46).

W. R. Waggoner (M '46), rate advisor, Southern Services, Inc., Birmingham, Ala., retired recently. He was born August 23, 1887, at Columbus, Ohio, and was graduated from Case Institute of Technology in 1910 with a bachelor of science degree in electrical engineering. After leaving college Mr. Waggoner entered the Doherty student engineering course at Denver, Colo., and was subsequently employed for 13 years in various supervisory capacities with operating subsidiaries of Cities Service Company. He was chief engineer of the Montgomery (Ala.) Light and Water Power Company at the time that company was acquired by Alabama Power Company in 1923. He took a position with the new company and moved to Birmingham. He has held positions as sales engineer, assistant sales manager, and head of the rate department, and since 1928 he has been rate engineer and rate advisor with Southeastern Power and Light Company, Commonwealth and Southern Corporation, and Southern Services, Inc. He is a member of the Edison Electric Institute and the Engineers Club of Birmingham.

T. J. MacKavanagh (M '13, F '34, Member for Life), professor and chairman of the electrical engineering department, Catholic University of America, Washington, D. C., retired August 31, 1952. He will continue his activity in the legal and engineering fields as a private consultant. He was born in Scotland and received his first engineering degree from the Royal Technical College of Glasgow. He served as chief engineering officer on the Anglo-American Telegraph Company cable ship, *Minia*, from 1905 to 1912. He was a lecturer at the Nova Scotia Technical School for 3 years, during which time he obtained his bachelor of science degree in electrical engineering. Coming to the United States in 1914, he was assistant professor of electrical engineering at the University of Michigan until he came to Washington, D. C., in 1918 to join the staff of the Potomac Electric Power Company. He joined the faculty of the Catholic University in 1918 as chairman of a division in the School of Engineering and Architecture which later became the Department of Electrical Engineering. He is a member of the Society for Promotion of Engineering Education.

C. J. Breitwieser (AM '33, M '44), executive assistant to the vice-president in charge of engineering, P. R. Mallory and Company, Inc., Indianapolis, Ind., has been promoted to director of engineering. He joined Mallory in June 1951, following service with Consolidated Vultee Aircraft Corporation, San Diego, Calif., as chief of electronics and head of the engineering laboratories. He has served the AIEE on the Committees on Air Transportation (1944–48); and Electronics (1948–52).

C. R. Ammerman (AM '49), professor of electrical engineering, Pennsylvania State College, State College; **G. W. Swenson** (AM '19, F '36), chairman, Department of Electrical Engineering, Michigan School of Mines and Technology, Houghton; **Albrecht Naeter,** (AM '23, M '30), chairman, Department of Electrical Engineering, Oklahoma Agricultural and Mechanical College, Stillwater; **E. B. Kurtz** (AM '20, F '29), chairman, Department of Electrical Engineering, State University of Iowa, Iowa City; and **O. W. Eshbach** (AM '17, F '37), dean, Northwestern Technological Institute, Evanston, Ill., have been named members of the National Advisory Board of Eta Kappa Nu. Dr. Kurtz, formerly national vice-president, succeeds to National President of the society.

J. H. Mulligan, Jr. (AM '44), assistant professor of electrical engineering, New York University, New York, N. Y., has been appointed chairman of the Department of Electrical Engineering. Dr. Mulligan joined the faculty of the university in September 1949. Previously he was chief engineer of the Television Transmitter Division, Allen B. Du Mont Laboratories, Inc., Clifton, N. J. Dr. Mulligan has been a joint co-ordinator of electrical engineering research for New York University during the past year. He is chairman of the New York Section of the Institute of Radio Engineers, a member of the American Physical Society, the American Mathematical Society, Tau Beta Pi, and Sigma Xi.

J. M. Wallace (AM '41, M '48), manager, Switchgear Distribution Apparatus Department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named manager of the Westinghouse Meter Division. Mr. Wallace joined the company in 1935 and held the positions of design engineer, section manager, engineering manager, and manager in the Switchgear Distribution Apparatus Department before his present appointment. In 1945 Mr. Wallace was named "the nation's outstanding young electrical engineer" by Eta Kappa Nu Association for his development of superior electric protective devices. He is the author of several technical articles and holds many patents for developments in the switchgear field.

R. S. Caruthers (M '47), member of technical staff, Bell Telephone Laboratories, Murray Hill, N. J., has joined the Lenkurt Electric Company, San Carlos, Calif., as chief systems engineer. He received his bachelor of science and electrical engineering degrees from the University of Maryland, and holds the master of science degree from the Massachusetts Institute of Technology.

E. W. Williams (AM '45), sales promotion manager, Line Material Company, Milwaukee, Wis., has been named sales manager. He joined the company in 1937 as field engineer. **A. R. Waehner** (M '48), sales manager, Capacitor and Railroad Sales, succeeds Mr. Williams as sales promotion manager.

G. R. Shuck (AM '19, M '20), professor of electrical engineering, University of Washington, Seattle, retired in June 1952. He received his engineering education at the University of Minnesota, where he was awarded a degree in electrical engineering in 1906. In 1918 he came to the University of Washington as an instructor in electrical engineering and rose to the grade of professor in 1937. He is a member of the Illuminating Engineering Society and holds a number of patents on electric meters. He has served as chairman of the Seattle Section of the AIEE (1940) and on the Committee on Instruments and Measurements (1940–41).

J. M. Walters (AM '51), system and sales engineer, RCA Victor Division, Radio Corporation of America, Atlanta, Ga., has been appointed broadcast field sales representative. Before joining RCA in 1950, Mr. Walters served with the Naval Research Laboratory, Washington, D. C.; the Federal Communications Commission; and as chief engineer of station *KPAC*, Port Arthur, Tex. He is a member of the Institute of Radio Engineers.

E. F. Adams (M '46), electrical pyrometry division, Weston Electrical Instrument Corporation, Newark, N. J., has been appointed assistant chief engineer of the company's Tagliabue Division. He joined Weston 29 years ago as a development engineer. He is a member of the Instrument Society of America, and is a committeeman of the American Standards Association.

J. C. Fink (AM '46), assistant to the vice-president in charge of engineering, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed engineering manager of industrial products. Mr. Fink was graduated from the Pennsylvania State College in 1927 and joined Westinghouse that same year. In 1948 he was named manager of the industry engineering department and in 1949 attained the position he held prior to this appointment. Mr. Fink has served the AIEE on the General Industry Applications Committee (1947–52).

S. H. Van Wambeck (AM '39, M '47), director of research and engineering, Knapp-Monarch Company, St. Louis, Mo., has joined the Hammarlund Manufacturing Company, New York, N. Y., as chief engineer. He is a former professor of electrical engineering at Washington University, St. Louis, and has instructed at both Oklahoma Agricultural and Mechanical College and Rice Institute. He is a member of the American Society for Engineering Education and the Institute of Radio Engineers.

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Harold Goldberg (AM '35, M '44), chief, Section 4, Division 13, National Bureau of Standards, Washington, D. C., has been named chief of division 17, Ordnance Development Program C. Dr. Goldberg attended the University of Wisconsin and from 1945 to 1947 was principal research engineer for Bendix Radio Division, Bendix Aviation Corporation, on problems of microwave research and development. In September 1947 Dr. Goldberg joined the National Bureau of Standards as chief of the Ordnance Research Section, Ordnance Development Division. In June 1950 he was appointed as one of the assistant chiefs of Division 13, in addition to his duties as section chief. In August 1951 he became chief of Branch B of the Ordnance Development Division.

G. W. Griffin, Jr. (AM '50), manager, General News Bureau, General Electric Company, Schenectady, N. Y., has joined Sylvania Electric Products Inc., New York, N. Y., as director of public relations. A graduate of the University of Minnesota School of Business Administration, Mr. Griffin joined the General Electric Company in 1936. While on duty with the United States Army from 1941 to 1945, he served as executive public relations officer of the Eastern Defense Command. Shortly after returning to General Electric, he became manager of the News Bureau.

J. M. Woodmansee (AM '48), vice-president, Electrical Engineers Equipment Company, Melrose Park, Ill., has been appointed president of the company. He started with Electrical Engineers Equipment in 1934, working at first in the manufacturing departments and later in other departments. After serving with the United States Navy from 1943 to 1945, he returned to the company and was appointed assistant to the president and elected to the board of directors. He was appointed vice-president in 1946.

A. K. Alsaker (AM '39, M '50), assistant to chief engineer, Delta-Star Electric Company, Chicago, Ill., has been appointed assistant chief engineer. Mr. Alsaker received his bachelor of science degree from Northwestern University in 1936 and his master of science degree from California Institute of Technology in 1938. He joined Delta-Star in 1941 and was development engineer when he entered the United States Navy in 1943. He returned to the company in 1946 and progressed through design engineer and head of the laboratory to his present position.

H. C. Martel (AM '51), graduate student, California Institute of Technology, Pasadena, has been awarded a renewal of his Radio Corporation of America Fellowship. He received his bachelor of science degree in engineering at California Institute of Technology in 1949 and his master of science degree at the Massachusetts Institute of Technology a year later. He was awarded the fellowship last year for further graduate study in electrical engineering and received the renewal to complete his requirements for the doctor of philosophy degree. He is a member of Sigma Xi, Tau Beta Pi, and the Institute of Radio Engineers.

A. W. Tracy (AM '50), district manager, Anaconda Wire and Cable Company, Denver, Colo., has been named district manager of the company's Los Angeles (Calif.) office.

J. D. Seaver (AM '49), engineer, Meter and Instrument Laboratory, General Electric Company, Lynn, Mass., has been named assistant manager, Industrial Heating Department. He will make his headquarters at Schenectady, N. Y. Mr. Seaver has been associated with General Electric since 1935.

B. B. Finigan (AM '51), cadet engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been assigned to the New York (N. Y.) District Sales Office. He is a graduate of Norwich University and joined Reliance 2 years ago.

J. J. Clarkson (M '49), engineering manager, Fractional Horsepower Motor Division, General Electric Company, Fort Wayne, Ind., has been appointed general manager of the Specialty Motor Sub-Department. Mr. Clarkson was graduated from the University of Alabama with a bachelor of science degree in electrical engineering in 1929 and joined General Electric that same year.

Herman Halperin (AM '21, F '45), senior staff engineer, Commonwealth Edison Company, Chicago, Ill., has been elected to Eta Kappa Nu by the Illinois Institute of Technology chapter. Mr. Halperin was the only man from industry elected. He has served on numerous AIEE committees including Protective Devices, Research, Insulated Conductors, Technical Program, Standards, and others.

C. H. Wilts (AM '48), assistant professor of electrical engineering, California Institute of Technology, Pasadena, has been named associate professor. He has served on the AIEE Committee on Feedback Control Systems (1949–50).

G. C. Brown (AM '22), Electrical Utility Department, Westinghouse Electric Corporation, New York, N. Y., has been named assistant manager of the department. A native of Williamsport, Pa., and an electrical engineering graduate of the University of Cincinnati, Mr. Brown has held various positions with Westinghouse since 1923 and has served with the Electrical Utility Department since 1927.

F. L. Cater (M '32), consulting engineer, W. R. Grace and Company, New York, N. Y., has been appointed chief engineer of the Industrial Department of the company. Mr. Cater is a member of the Institution of Mechanical Engineers and the Institution of Electrical Engineers, both British societies.

R. B. Steinmetz (AM '26, M '48), general manager of mills, Anaconda Wire and Cable Company, New York, N. Y., has been appointed vice-president in charge of manufacturing operations. He has been with the company since its inception. **D. E. Allen** (AM '23), sales manager of the company, has been named general sales manager. He joined Anaconda Wire and Cable in 1932.

H. W. Zang (AM '49), electrical engineer, Giffels and Vallet, Inc., Detroit, Mich., has been appointed to the staff of the Gaseous Diffusion Plant, Oak Ridge, Tenn., operated by Carbide and Carbon Chemicals Company.

C. A. Maynard (AM '39), director of research and engineering, Indiana Steel Products Company, Valparaiso, has been appointed vice-president of the company. Mr. Maynard has been with Indiana Steel since 1932 and has been head of research and engineering since 1947.

OBITUARY • • • •

William Savage Turner (AM '86, M '88, F '13, Member for Life) partner, William S. Turner and Company, Portland, Oreg., died on August 13, 1952. Mr. Turner was born in Quincy, Ill., on August 15, 1858. He received his bachelor of science degree from Knox College in 1879 and a master of science degree from Cornell University in 1886. In that year he joined the Westinghouse Electric Manufacturing Company (now the Westinghouse Electric Corporation) as a construction foreman. He joined in forming the firm of Woodbridge and Turner in 1888, engaged in designing and constructing street and interurban electric railways, lighting, and power plants. In 1899 he joined J. G. White and Company and served from 1901 to 1904 as managing engineer and New Zealand representative in charge of construction and equipment of the Auckland Electric Tramways, Auckland, New Zealand. In 1908 he became managing engineer, northwestern office, Portland, for W. S. Barstow and Company. He became a consulting engineer in Portland in 1911 and in 1921 formed William S. Turner and Company, manufacturers. Mr. Turner was one of the early pioneers in the electric street railway construction and the installation of electric power plants. He was a member of the American Society of Civil Engineers and the Oregon Society of Engineers. He had served on the AIEE Membership Committee (1914–15).

Charles G. Smith (AM '37), electrical engineer for Palo Alto (Calif.) Electric Department drowned August 26, 1952, while struggling to save his family after a boating accident. Mr. Smith was born in Mount Hope, Kans., on November 9, 1910, and was graduated from Stanford University in 1932. He was associated with Pacific Gas and Electric Company until 1945 when he assumed the Palo Alto post. He was a member of Sigma Xi.

Lawrence M. Cargo (AM '06, Member for Life), retired, Westinghouse Electric Corporation, Denver, Colo., died on August 14, 1952. Mr. Cargo was born on April 28, 1868, in Pittsburgh, Pa. He joined the Westinghouse Electric Manufacturing Company (now Westinghouse Electric Corporation) in 1887 as a drafsman. Before transferring to Denver in 1897, he had served as personal engineer to George Westinghouse and was in charge of the manufacture of the first incandescent light bulbs for the Chicago (Ill.) World's Fair in 1893. At the time of his retirement in 1937, he was Executive Representative for the Western District of the Westinghouse Corporation. Mr. Cargo was one of the founders of the Electric League in Denver.

Herbert Burns Colby (AM '42, M '51), System Maintenance Engineer, Public Service Company of Colorado, Denver, died on July 30, 1952. Mr. Colby was born in Junction City, Kans., on October 19, 1902, and was graduated from the University of Colorado in 1932. He was associated with the Public Service Company of Colorado from 1924 until the time of his death. Mr. Colby was a Registered Electrical Engineer in Colorado, a member of the Colorado Society of Engineers, and Eta Kappa Nu.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of September 18, 1952, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Adams, D. K., application engineer, General Electric Co., Schenectady, N. Y.
Alley, R. E., Jr., member of technical staff, Bell Telephone Laboratories, Murray Hill, N. J.
Anderson, J. P., James P. Anderson Co., consulting engineers, Omaha, Nebr.
Anderson, R. L., asst. professor, Calumet campus, Purdue University, Hammond, Ind.
Armstrong, F. C., asst. div. operating supt., Public Service Co. of Northern Illinois, Joliet, Ill.
Auld, N. C., div. supt., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Bauerschmidt, G. J., supervising engineer, Commonwealth Edison Co., Chicago, Ill.
Beals, A. T., chief engineer, Electro-Switch & Controls Inc., Culver City, Calif.
Bower, K. O., asst. control dev. engineer, Electro-Switch Div., General Motors Corp., La Grange, Ill.
Braunfeld, M. T., electrical engineer, General Electrosonics, Inc., New York, N. Y.
Britton, J. R., superintendent, The Hawaiian Electric Co., Ltd., Honolulu, Hawaii
Carleton, J. T., supervisory engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Cloyes, H. S., personnel supervisor, New York Telephone Co., Albany, N. Y.
Dana, D. W., section supervisor, General Electric Co., Lynn, Mass.
Dawson, C. H., assoc. professor, Engineering Div., University of Rochester, Rochester, N. Y.
Edwards, D. E., industrial sales engineer, lighting dept., City of Seattle, Wash.
Fasick, R. C., engineering instructor, Western Electric Co., Inc., Chicago, Ill.
Fitts, J. A., engineering representative, The Electric Storage Battery Co., Chicago, Ill.
Ford, W. A., electrical design engineer, Lee-Factors, Inc., Freeport, Tex.
Fujimura, Y. J., associate electrical engineer, Water & Power Dept., City of Los Angeles, Calif.
Garcia, V. M., electrical engineer, 1357 Ponce de Leon Ave., Santurce, Puerto Rico
Glassow, F. A., chief engineer, aircraft controls dev., Barber-Colman Co., Rockford, Ill.
Gleason, L. L., assoc. electrical engineer, lighting dept., City of Seattle, Wash.
Greenwood, G. E., asst. elec. apparatus engineer, The Detroit Edison Co., Detroit, Mich.
Grim, S. H., engineer, Consolidated Edison Co. of New York, Inc., New York, N. Y.
Herlitz, I., vice-pres. & manager, transformer switchgear, Allmanna Svenska Elektriska Aktiebolaget, Vesteras, Sweden
Hodgkinson, W. A., engineering lecturer, Newton Heath Technical College, Manchester, England
Jones, C. C., senior engineer, Alabama Power Co., Birmingham, Ala.
Kerr, W., instructor, Elec. Engg. Dept., University of Michigan, Ann Arbor, Mich.
Klos, E. R., project officer, Naval Ordnance Unit, Key West, Fla.
Koch, J. W., chief engineer, KFEQ Inc., St. Joseph, Mo.
Lauder, A., works mgr., Phillips Electrical Works, Ltd., Brockville, Ontario, Canada
Mason, V. V., research engineer, Hydro Electric Power Commission of Ontario, Toronto, Ontario, Canada
Matthysse, I. F., chief design engineer, Burndy Engineering Co., Norwalk, Conn.
Maynard, M. J., senior project engineer, Federal Tele communications Laboratories, Nutley, N. J.
McCord, C., electrical engineer, Tennessee Valley Authority, Knoxville, Tenn.
McKinney, H. R., electrical engg. associate, Water & Power Dept., City of Los Angeles, Calif.
Metz, L. P., control engg. supervisor, Westinghouse Electric Corp., Philadelphia, Pa.
Metzger, C. J., asst. to president, Hatzel & Buehler, Inc., New York, N. Y.
Meudell, A. Y., Jr., manager, General Electric Co., Bakersfield, Calif.
Miller, R. P., engineer, Southwestern Power Administration, Tulsa, Okla.
Moore, R. R., manager, Engg. Sales Div., Electric Storage Battery Co., Philadelphia, Pa.
Musler, A. A., electrical engineer, Union Electric Co. of Missouri, St. Louis, Mo.
Newman, F. W., asst. to div. engineer, General Electric Co., West Lynn, Mass.
Pflieger, A. B., supervisor & application engineer, The Electric Storage Battery Co., Philadelphia, Pa.
Poland, M. G., chief, Elec. Design Unit, Bonneville Power Administration, Portland, Oreg.
Price, F. W., supervising engineer, Westinghouse Electric Corp., Philadelphia, Pa.
Rieke, J. W., member of technical staff, Bell Telephone Laboratories, Murray Hill, N. J.
Rile, J. C., member of technical staff, Bell Telephone Laboratories, New York, N. Y.
Ryden, S. W., engineer, Illinois Bell Telephone Co., Chicago, Ill.
Sather, K. M., asst. engineer, Pacific Gas & Electric Co., San Francisco, Calif.
Schleinkofer, G. N., supervising engineer, Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Schuler, C. R., section engineer, Commonwealth Edison Co., Chicago, Ill.
Sebrell, E. W., transportation engineer, General Electric Co., San Francisco, Calif.
Seely, R. E., design engineer, General Electric Co., Fort Wayne, Ind.
Siegal, A., partner, Selo Electric Co., Seattle, Wash.
Smith, E. J., senior research associate, The Polytechnic Institute of Brooklyn, N. Y.
Snyder, A. T., engineer, Boeing Airplane Co., Seattle, Wash.
Sproul, W. W., Jr., sales manager, Westinghouse Electric Corp., Pittsburgh, Pa.
Stanley, H. C., supervising engineer, General Electric Co., Pittsfield, Mass.
Sterrett, P. S., plant manager, Tuco station, Southwestern Public Service Co., Abernathy, Tex.
Thomas, J. H., apparatus specialist, Westinghouse Electric Supply Co., Milwaukee, Wis.
Tillin, I., electrical engineer, San Francisco Navy Shipyard, San Francisco, Calif.
Tuttle, A. D., special studies engineer, New York State Electric & Gas Corp., Binghamton, N. Y.
Vanderleck, J. M., testing engineer, The Hydro Power Commission of Ontario, Toronto, Ontario, Canada
Wallace, B. W., regulation engineer, The Toledo Edison Co., Toledo, Ohio
Warren, J. D., electrical supervisor, Louisville Gas & Electric Co., Louisville, Ky.
Wilkinson, H. M., engineer, Computing Devices of Canada, Ottawa, Ontario, Canada
Willert, W. W., motor project engineer, Apex Electric Manufacturing Co., Sandusky, Ohio.
Williams, T. W., inventory & costs engineer, The Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Wilsey, H. R., member of technical staff, Bell Telephone Laboratories, Whippany, N. J.
Woodward, J. P., distribution service engineer, Union Electric Co. of Missouri, St. Louis, Mo.
Yelderman, G. R., sales engineer, General Electric Co., El Paso, Tex.
Zahorsky, L. A., chief motor project engineer, Lear, Inc., Grand Rapids, Mich.

74 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before November 25, 1952, or January 25, 1953, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

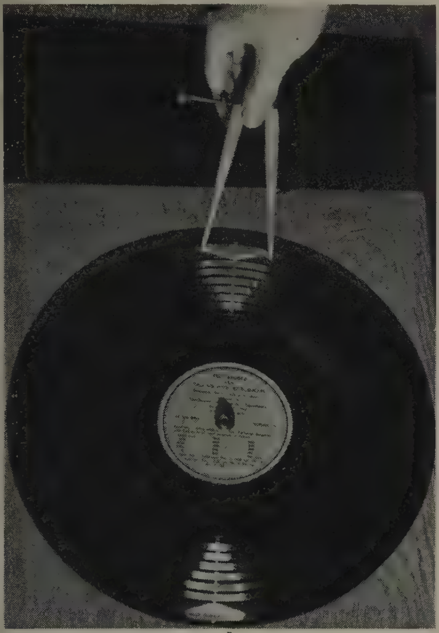
Burrill, C. M., RCA Laboratories, Princeton, N. J.
Maylott, C. F., Scintilla Magneto Div., Bendix Aviation Corp., Sidney, N. Y.
Rao (Green), M.V.S., Indian Radio & Television College, Madras, India
Ryan, A. H., Electricity Div., Naval Research Lab., Washington, D. C.
Shen, D. W. C., Adelaide University, Adelaide, South Australia

5 to grade of Member

OF CURRENT INTEREST

NBS Develops Spectroscopic Method for Studying Speech Characteristics

The spectroscopic method, a simple yet highly effective technique for visual analysis of speech sounds, has been developed by the National Bureau of Standards (NBS). The Bureau is conducting an investigation of the many problems involved in recording and reproducing human speech. The present program is the outgrowth of assistance which the Bureau rendered the Library of Congress in improving the quality of "talking books," voice recordings of selected literature which the Library supplies to the blind. In addition to performance studies of recording and reproducing equipment, new and improved methods of tests were worked out, and new types of recording media were investigated. In the course of this work, the spectroscopic technique was developed.



Direct calibration of a talking-book record by reflection of light from the groove faces. Measurements of the triangular pattern produced by a collimated beam of light striking the record from the left are used to compute the modulation of the record at test frequencies

In talking books high fidelity is especially important because most of the material is unfamiliar to the listener, and he has no easy way of checking his impression of the words he hears against the printed words in the book. Because of this, talking-book recordings must have higher fidelity than is usual even in good musical recordings. Special, high-quality records and reproducing equipment are thus required. As the Library has invested several million dollars in talking books, it requested the Bureau to investigate talking-book production techniques in current use and to set up specifications for the purchase of records and reproducers.

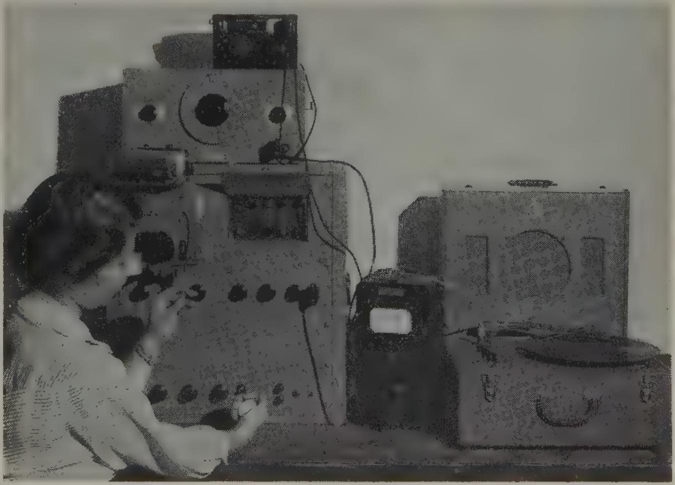
The program began with the preparation of an interim specification for talking-book phonographs. When sample reproducers were tested for compliance with this specification, large variations were found in such characteristics as tip radius of the reproducer needle, tone-arm force, and loudspeaker response. It was also evident that standardization of record characteristics was needed; arrangements were therefore made with two of the largest suppliers of talking-book records for a co-operative study of their recording techniques, with the ultimate object of developing a standard technique.

Since there were no established methods for testing speech records, it was necessary for the Bureau to devise a new technique for studying speech communication systems. This technique, developed by Edith L. R. Corliss and associates of the Bureau staff, utilizes a time-integrated spectrogram of speech sounds which can be interpreted to show many of the characteristics of the transmitting system. Although single speech sounds, or syllables, are complex patterns of different frequencies and sound levels, over a relatively short period of time nearly all sound levels and frequencies within the entire speech spectrum are produced. The characteristics of a recording system thus can be determined by comparing an integrated spectrogram of the human voice with an integrated spectrogram for the recording system.

To provide the necessary sound spectrograms, a commercial spectrograph known as a Panoramic Analyzer was modified in the Bureau's sound laboratory. Ordinarily the Panoramic Analyzer sweeps through the audio-frequency range once a second and displays a spectrum of the signal at its input on the face of a cathode-ray tube. The horizontal co-ordinate of the pattern is a frequency scale; the vertical display is proportional to the amplitude of each frequency contained in the input signal. Because speech sounds change in composition more often than once a second, many of the frequencies present in a sample of speech would not be included in a 1-second sweep. It was therefore necessary to modify the Panoramic Analyzer so that it would sweep through its analysis range at the syllable articulation rate. This made it possible to display instantaneous spectrograms of individual syllables on the cathode-ray screen when the equipment was connected to the output of a microphone. By exposing photographic film for sufficient time (at least 60 seconds) to successive syllable spectrograms, an integrated envelope characteristic of the speech communication system under study is obtained.

A simple optical procedure, previously developed by Buchmann and Meyer in Germany, is used to relate these integrated spectra to the actual characteristics of the talking-book disks as manufactured. In

Instantaneous spectrograms of individual syllables produced by the record player at right appear on the oscilloscope screen at left. The camera above the screen is used to take a time exposure of the successive syllable spectrograms



Future Meetings of Other Societies

American Society for Quality Control. 7th Midwest Conference. November 20–21, 1952, Claypool Hotel, Indianapolis, Ind.

American Society of Refrigerating Engineers. 48th Annual Meeting. November 30–December 3, 1952, Hotel Commodore, New York, N. Y.

American Standards Association. 34th Annual Meeting. November 25, 1952, Waldorf-Astoria Hotel, New York, N. Y.

Industrial Management Society. 16th Annual Time and Motion Study and Management Clinic. November 5–7, 1952, Sheraton Hotel, Chicago, Ill.

National Electrical Manufacturers Association. November 10–13, 1952, Haddon Hall, Atlantic City, N. J.

National Exposition of Power and Mechanical Engineering. 20th National Power Show. December 1–6, 1952, Grand Central Palace, New York, N. Y.

The American Society of Mechanical Engineers. Annual Meeting. November 30–December 5, 1952, Hotel Statler, New York, N. Y.

this procedure, the pattern formed by reflection of a collimated beam of light from the groove faces of a record—made up of a series of single-frequency bands—is measured and used to calibrate the modulation of the record directly, eliminating the effect of the reproducer system. After a test record has been calibrated in this way, the integrated frequency spectrograms of the talking books under study are compared with the spectrogram of the calibrated test record.

The spectrographic method developed by NBS offers a powerful tool for the study not only of speech communication systems but of the nature of speech itself. Previous methods for visually observing speech characteristics either required the repeated playing back of a recording in order to make a frequency analysis, or else sacrificed a certain amount of resolving power by using fixed-frequency band filters and multiple channels to obtain the necessary high speed. The Bureau's method, on the other hand, allows direct observation of the location of the peak frequencies making up speech sounds and of their relative magnitudes with a resolving power equivalent to that of the fixed band filters, but it operates through a single channel. Thus, the modifications in the structure of the speech sounds produced by either the recording process or the reproducer system may be determined with some precision. The statistical occurrence of speech sounds and their inherent variability can be studied.

The Bureau hopes to make further studies of the new method for analyzing speech communication systems. Interesting subjects for investigation include the statistical distribution of sound levels and frequencies in speech, the amount of time needed for obtaining representative samples of speech recordings, and the effect which such properties as frequency-range restriction, noise, resonances, and harmonic distortion have on the photographed pattern.

Aluminum Alloy Enables Manufacture of More Powerful Steam Turbine-Generators

Development by the General Electric Company of a new alloy called "Cond-Al" has enabled the company to begin manufacture of steam turbine-generators which are 35 per cent more powerful than any of their type now in existence. The outcome of 8 years of research, Cond-Al is composed of aluminum, with very small quantities of iron, magnesium, and silicon.

The alloy's light weight, high conductivity, and resistance to various stresses in high-speed high-temperature operation remove a previous limitation on the size of turbine-generators and may open a new era in the evolution of the steam turbine-generator.

Manufacture of the first four turbine-generators to use the new alloy is under way, with the first unit slated for completion this fall. Each of the units is rated at 216,000 kva and will operate at 3,600 rpm. The world's largest and most powerful turbine-generator of this type at the present time is a 160,000-kva machine. Units rated at higher than 300,000 kva are now being developed.

The new 216,000-kva units, when assembled, will each weigh more than 700 tons and will be nearly 82 feet long, 17 feet wide, and more than 10 feet high above floor level. Because of their size, the stator, or frame, of each of the units will be too large for shipment as a unit. A method of double-frame construction has been developed for the new type of turbine-generators.

Earlier steam turbine-generators operated at 1,800 rpm. With the growing need for increased efficiency and economy in power production, machines operating at 3,600 rpm were designed and developed. For the next 25 years conventional copper field windings were satisfactory in the high-speed generators.

As the demand grew for larger turbine-generators, conventional field windings were found to have certain limitations when used in larger generator rotors revolving at high speed and under very high temperatures

Research was begun to solve the problem, and after many different alloys were tested, the Cond-Al formula was perfected.

C. H. Holley, left, and H. D. Taylor are shown inspecting field windings using Cond-Al in a 216,000-kva generator

EMC Urges Deferment Requests Follow 19-Step Outline

Engineering Manpower Commission (EMC) of Engineers Joint Council has recommended a 19-step outline to aid employers in preparing requests for draft deferments for their key engineers and scientists. This outline was prepared by the Scientific Advisory Committee of the Selective Service System to aid in evaluating certain occupational deferment requests that were referred to them by the Director of Selective Service. This outline has been circulated to local boards through Volume II, Number 7, of *Selective Service*.

The "Outline For An Occupational Investigation" is as follows: (1) What is the training and educational history of the registrant? Where did he stand in his class (if information is available)? (2) What was his employment experience prior to job with present employer? (3) What was the nature of his previous job assignments with present employer? (4) What are his employment assignments on present job? (5) What is the size, nature, and function of the group registrant is assigned to as a worker? (6) What is the registrant's function in the group? (7) What are the products on which the registrant is working and what is their end use? If he is not working on a product, what are the services in which he is engaged? (8) What is the relation of these products or services to national health, safety, and interest? (9) What is the relation of these products or services to defense or mobilization? (10) What is the range of salaries on this job and what is the average salary of comparable employees? What is the salary of the registrant? (11) What is the frequency with which nonprofessional personnel are hired in a similar category? (12) Is a formal period of training customary for the job? What is its scope? (13) How long does the training program last? (14) If the registrant is on a training program, how long has he been on it? (15) What is the registrant's effectiveness in relation to his fellows?

(16) What success and/or difficulties has the employer encountered in recruiting for the registrant's type of job? (17) What are the shortages or overages in this category of employment in the registrant's plant? Nationally? (18) If classified previously in II-A, how long has he been so classified? (19) To what extent has the employer already lost employees to the Armed Services in the category of the registrant?

EMC urges employers to provide full answers to these questions when requesting deferments. If this is done employers are more apt to receive favorable decisions at the local level and in any event will certainly be providing full information should appeals be necessary.

Employers are also reminded by EMC of the necessity for appealing adverse decisions received with respect to occupation deferments. Unless the employee is valuable enough for appeals to be made, then it is most probable that no deferment should have been requested in the first place.

Employers of Professional Engineers Warned Regarding Wage Stabilization

The Office of Salary Stabilization has released Interpretation Number 12, defining the scope of the amendment to the Defense Production Act which excludes from stabilization the salaries and other compensation of professional engineers. Joseph D. Cooper, Executive Director of the office, stated that it was the intent of Congress to limit this exemption specifically to "professional engineers employed in a professional capacity."

Employers with salary plans are warned by Mr. Cooper that granting increases to professional engineers under this exemption will not be basis for modification of the plan with respect to granting raises to other employees.

Mr. Cooper said that in Interpretation Number 12 the meaning of "professional engineer" and "employed in a professional capacity" were spelled out not only to assist employers in determining the personnel who are exempt, but also to guard them against taking actions that might be in contravention of the Act and regulations.

The interpretation is as follows:

A "professional engineer" is defined as: (*a*) a person who, by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience, is qualified to apply such special knowledge for the purpose of rendering professional services or accomplishing creative work, such as the consultation, investigation, evaluation, planning, design, or supervision of construction for the purpose of assuring compliance with specifications and design in connection with structures, machines processes, works, or projects; (*b*) a person qualified by reason of his professional education, if he holds a professional engineering degree from a college, university, or institute of technology, authorized under the laws of the jurisdiction in which it is located to grant academic degrees in professional engineering; (*c*) a person licensed or registered to practice as a professional engineer in any state, territory, or possession of the United States or in the District of Columbia.

Persons engaged in carrying on routine mechanical activities, technicians, artisans, advisers on sales promotion, business methods, stationary engineers, maintenance engineers, sales engineers, management or administrative engineers, physicists, chemists, mathematicians, engineering assistants, are not professional engineers.

The statutory exclusion from salary stabilization extends to a professional engineer only if he is employed in a professional capacity. A person is so employed if he performs engineering work of a professional character within the meaning of the Regulations, Part 541, issued by the Administrator of the Wage and Hour and Public Contracts Divisions pursuant to Section 13(a)(1) of the Fair Labor Standards Act of 1938, as amended.

A person, qualified as a professional engineer, may actually be employed in a position which does not involve the duties or responsibilities of a professional engineer. Such a person is not regarded as being employed in a professional capacity, even though he may be employed by a professional engineer or a firm of professional engineers.

New Giant Telescopes Will Study Sun's Corona

The two largest and most powerful and accurate instruments ever built to study the sun's corona have been developed for installation in high-altitude dust- and haze-free observatories atop Fremont Pass in the Colorado Rockies, and on Sacramento Peak, near High Rolls, N. Mex. After completion of "dry runs" on these instruments, called coronagraphs, using electronic devices to double for the missing giant lens and sun, special optical systems and instruments will be installed. The first one completed will be located at Sacramento Peak and is scheduled to be in operation by this fall.

Scientists, through use of the two giant telescopes, hope to gain additional information about the sun's corona that will: (1) make possible highly-accurate long-range terrestrial weather forecasting; (2) enable further progress in forecasting sun-caused disturbances that often blackout or cripple the world's radio communications and interfere with radar operation; (3) unlock additional secrets of the atom; and (4) yield further keys to supersonic flight in the stratosphere and even higher—into the ionosphere and above.

The instruments were designed by astronomers of Harvard College Observatory and the High Altitude Observatory of Harvard University and the University of Colorado.

Coronagraph mounted for testing

By creating a perpetual total eclipse of the sun's bright face, the coronagraph makes possible continuous daytime photographic, spectrographic, and visual study of the sun's corona. Prior to development of the coronagraph in 1930, such studies were not possible except at times of infrequent and brief total solar eclipses in widely scattered locations on the earth, many of them inaccessible.

An "occulting disk" located in the coronagraph's optical system blacks out or "occults" the bright face of the sun, creating an artificial total eclipse, thus permitting study of the corona surrounding the sun.

Instead of the tapering metal tube of the familiar refracting telescope, the coronagraph has a long, boxlike rectangular spar of fabricated steel plate. This spar serves as a 4-surfaced table 26 feet long and 40 inches by 32 inches in cross section. On its outer surfaces, the Observatory scientists can mount as many as 11 complete optical systems and other devices for solar research.

Each coronagraph has an electronic guider device actuating sensitive controls and electric motors that will keep the spar automatically and accurately aimed at the sun as the earth turns on it axis and move through space.

As its exact center, the spar is supported on a heavy cast-iron base. A "polar axis" shaft, aligned on the North Star, permits the spar to be rotated from east to west to counteract the earth's rotation.

Bearing hubs on the stub of the polar axis shaft permit movement of the spar north and south through an arc of ±25 degrees from the plane of the earth's equator. Movement on this axis compensates for the seasonal variation of the sun's path.

To ensure always-accurate alignment of the various optical systems on the sun, surfaces of the spar must not bend more than one thousandth of an inch regardless of the spar's position. Bending is prevented by using an inner truss spar that supports the outer spar through a system of multiple hydraulic bellows and counterweights. These compensate for the bending pull of gravity.

Despite its great weight and size, the spar will be so delicately balanced and literally floated on a thin film of oil by "oil pad bearings," that an electric motor rated at only one 4/1000 horsepower will drive the 14-ton mechanism as it follows the sun.

UPADI Second Convention Held in New Orleans, La.

Engineers Joint Council (EJC) and Engineering Institute of Canada were cohosts to the Second Convention of Panamerican Federation of Engineering Societies (UPADI), August 25–29, 1952, in New Orleans, La. Fourteen countries were represented at the convention which had a total registration of 314. The countries were Argentina, Brazil, Canada, Chile, Colombia, Cuba, Dominican Republic, Mexico, Panama, Paraguay, Peru, Puerto Rico, United States, and Uruguay.

The convention elected as its president Carlton S. Proctor, President, American Society of Civil Engineers. Other officers were Manuel J. Puente, Cuba, first vice-president; Saturnino de Brito, filho, Brasil, second vice-president; and as Secretaries: S. E. Reimel, United States, Rodolfo Ballester, Argentina, Juan V. Cabrerizo, Peru, Hector Cassaigne, Mexico, J. B. Stirling, Canada. The convention by acclamation elected Luis Giannattasio, Uruguay, Honorary President. Dr. Giannattasio is currently president of UPADI.

The local organizing committee was under the direction of James M. Todd (F '45), who was also chairman of the United States delegation. Tulane University provided the facilities for the meetings.

The principal business of the convention was the adoption of a Constitution and Bylaws. It was agreed to finance the organization through a UPADI fund, and a budget for the coming year in the amount of $15,000 was adopted. Committees were established on administration, professional ethics, relations with other organizations, and technical matters. The convention decided to hold its next meeting in 1954 in São Paulo, Brazil.

One full day was devoted to the presentation of papers on aspects of engineering education in the hemisphere. Deans of engineering schools in Canada, United States, and Latin America participated in the program. The concluding feature of the convention was a group of papers on the "Economic Development of Latin America."

A highlight of the convention was the presentation by Dr. Giannattasio of a bronze plaque commemorating the Second UPADI Convention in New Orleans. Carlton Proctor accepted the plaque on behalf of the EJC. The Engineering Institute of Canada presented plaques bearing the coat of arms of Canada to each of the delegations present.

A number of side trips were organized for the delegates including the Kaiser Aluminum Works, the Port of New Orleans, the United States Experimental Waterways Station in Vicksburg, Miss., and the Freeport Sulphur Company.

Left to right: Manuel J. Puente; Dean Fred Cole, Tulane University; T. G. LeClair (F '40), president, EJC; Luis Giannattasio, president, UPADI, and Mayor deLesseps S. Morrison of New Orleans at the welcoming luncheon of the UPADI convention

Radioactive Pen Point Detects Atmospheric Changes

A pen that writes the weather has proved an accurate means of detecting atmospheric changes for General Electric Company scientists in Schenectady, N. Y.

The device puts down on paper weather changes ranging from distant summer showers to onrushing thunderstorms.

With the aid of a radioactive point on a slender shaft mounted atop the Research Laboratory, scientists are gauging the electrical activity generated by weather changes as slight as shifting winds. Even variations in intensity of light reflected from clouds sometimes register noticeable changes on the recording mechanism.

Electric current, collecting on the radioactive point from high potential developed between earth and atmosphere, is measured by an extremely sensitive photoelectric recorder located in the laboratory's penthouse weather station.

The tiny stylus of the apparatus moves left when negative charges grow on the antenna outside. Positive charges move the pen to the right. Dead center is zero potential on the paper chart moving steadily past the red-writing stylus.

With clear skies overhead, small deflections of the delicate instrument correlate well with the outbreak of showers within a radius of 450 miles.

On clear days the pen stays close to the center line of the chart. But radium-impregnated gold foil on the antenna has made it so sensitive the pen seldom remains at rest. When thunderstorms move into the area, the pen springs to life. The approach of a storm consistently builds up a negative charge, sending the thin red line far to the left on the ruled paper.

Lightning flashes reverse the pen. It moves quickly to zero, and at times swings over to a positive position. The approach or passage of cold and warm fronts write easily identified patterns on the chart. A build-up on the negative side usually heralds a warm front. A positive reading in most cases identifies the cold.

The pen has indicated the approach and passage of a line squall by inscribing a jagged pattern on a moving paper chart. Approach of the storm built up a negative electric potential on a radioactive antenna outside the penthouse weather station. This potential moved the automatic pen to the left of center on the lower portion of the chart (first approach of the storm) despite blue skies and fleecy clouds outside. As the squall drew nearer, the leftward movement of the pen increased

Freezing and sublimation (the direct conversion of vapor to ice) usually register a positive pattern. Melting and condensation touch off negative activity in the atmosphere.

Advantages looked for in the more widespread use of the weather device include closer pin-pointing of cold and warm fronts on the weather map. It also can be used to indicate the presence of fronts high in the atmosphere which otherwise might go undetected. Pen strokes across the chart can be used to count lightning flashes in the area.

Sharper short-range weather forecasts may result from the use of networks of these devices in weather stations across the country. The mechanism ferrets out isolated showers and disturbances not otherwise detected by most instruments now used in ordinary weather stations. The equipment can tip off weather men about the presence of disturbances which could be found otherwise only by radar. The device costs only a fraction of the price paid for radar equipment.

Use of Guided Missiles in Korea Revealed by United States Navy

The United States Navy is using guided missiles against the Communists in Korea. They are deadly and astoundingly accurate and represent a major triumph for research in push-button warfare.

The Navy gave the following account of

the missiles' use. A guide plane, carrying special electronic control equipment, is sent aloft. The missile, armed with a powerful warhead, is moved onto a catapult. A guide plane, aboard the aircraft carrier, sends the missile roaring skyward by means of electronic devices.

As the missile reaches a predetermined altitude, the air-borne guide plane then takes over and directs the weapon to the target area. At the time the missile is ready to make its pay-off dive, the guide plane is miles away, out of antiaircraft range.

All during its flight, from the deck of the carrier to the target, the progress of the missile is recorded in a specially equipped electronics room aboard the ship.

The missile is equipped with a television transmitter. Television receivers on the deck and in the guide plane give control officers the same view they would have in the missile's cockpit. The television screens enable the controlling officer to keep the missile "on the target" until the last second, giving it unbeatable accuracy.

Operations Research Society to Hold Meeting in November

The first regular meeting of the Operations Research Society, which was formed by a group of leading scientists in May 1952, will be held at the National Bureau of Standards, Washington, D. C., November 17 and 18, 1952.

The society, whose purpose is to promote the application of scientific methods to business and military problems, will hear and discuss papers involving industrial applications of Operations Research; waiting lines; inventories and the use of probability techniques in industry; and the newly-developed Monte Carlo method for handling problems which cannot be solved with ordinary equations. There also will be a research panel on the solution of new problems and the development of new methods which have arisen in industry in the last year.

Nonmembers are invited to attend the meeting and to register at the official headquarters at the Wardman Park Hotel, Washington, D. C.

Further information about the meeting may be obtained from the secretary of the society, John B. Lathrop, 30 Memorial Drive, Cambridge, Mass.

Engineer Shortage Discussed at Manpower Conference

Engineering Manpower Commission of the Engineers Joint Council discussed a program to insure fullest utilization of engineering skills in industry and military service at a recent conference held in conjunction with the Centennial of Engineering at Chicago, Ill.

The commission's chairman, Carey H. Brown, emphasized the need for withholding from the military service pool men with high technical and professional qualifications and a number of qualified trainees. These men, he said, are needed in industry if this country is to maintain its superiority in the productive fields.

However, Colonel J. D. Griffing of the Selective Service System told the conference that the prospect is for more, not fewer, engineers in the military services. He declared that engineers could not expect special privileges or exemption from military service.

Another speaker, Henry J. Taylor, expressed the opinion that if war is to be discouraged it must be done on the technological advantages and superiority of the United States.

Oak Ridge to Offer Courses in Radioisotope Techniques

The 30th, 31st, and 32d basic courses in radioisotope techniques in research will be offered by the Oak Ridge Institute of Nuclear Studies on January 5, February 2, and March 2, 1953.

Application blanks and other information on the 1-month courses may be obtained from Ralph T. Overman, Chairman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

Vacuum Bell Jar Discharge May Solve Flying Saucer Mystery

An electric discharge phenomenon produced in a vacuum bell jar at the Engineer Research and Development Laboratories, Fort Belvoir, Va., may be a possible solution to the mystery of "flying saucers," according to Noel W. Scott, physicist.

Working with the vacuum bell jar on experiments in mirror and lens coating, Mr. Scott produced an eerie orange object that bears a striking similarity to the flying saucers that many claim to have seen.

For the press, Mr. Scott demonstrated the saucers and made them behave very much like the real thing. He pumped air out of the bell jar to create a partial vacuum. The air left in the jar was electrified by discharge between highly charged electrodes. He then introduced air from the outside which caused a relatively bright glow to form on some portions of the positive electrode. By varying the amount of air introduced into the jar, the color of the saucers varied from orange-red to purple, pink to white. The introduction of helium into the chamber produced a green saucer.

The saucers were produced in many of the shapes that have been sighted to date. A wave of a magnet outside the jar and the laboratory-made saucers skirted elusively about the rim of the jar, stood still, reversed their fields, and in general behaved very much like the real things are said to behave. "The saucers," Mr. Scott said, "remain stationary, move at an excessive rate of speed or change direction almost instantly by altering the direction and intensity of the rays and the electric and magnetic fields, and by changing the atmospheric pressure. This may explain why airplanes, attempting to fly near them, have failed in detecting or sighting them. Once any factor responsible for the formation of this phenomenon is changed, the saucer might completely engulf an object, attach itself to it, repel it, or fade out completely." Mr. Scott also stated the saucers have enough substance to cause "blips" and be picked up on radar screens.

Mr. Scott said he came upon the saucers quite by accident and does not offer this explanation as the only answer to the nation-wide saucers problem. "It is just one theory," he said, "and not even a new one at that." This theory, the ionization or electrification of air, is well known in science and has been advanced before. Actually, what Mr. Scott did was to associate this theory with the flying saucers mystery that has kept the nation guessing since 1947. He did this by producing on the laboratory level, a phenomenon peculiar to the upper atmosphere.

Flying saucers are thought to possess the same family characteristics as other illuminating atmospheric phenomena. Mr. Scott believes that they probably lie somewhere between the two extremes of streak lightning and the multicolored Aurora Borealis.

During the press demonstration at the Laboratories, Mr. Scott repeatedly stated, "The atmospheric conditions necessary for producing this phenomenon are not the prevailing conditions that exist in the upper atmosphere. However, it is not altogether improbable that there may be occasional local conditions responsible for this glow which might be interpreted as flying saucers."

Industrial Television System Demonstrated by RCA

The first commercial model of the Radio Corporation of America (RCA) Vidicon system of closed-circuit industrial television was demonstrated on September 16, 1952, at a Baltimore and Ohio Railroad freight yard in Chicago, Ill.

The new Model *1TV-5* industrial television chain, representing a marked advance over experimental models previously demonstrated, is designed to afford maximum simplicity, compactness, ease of operation, good picture quality, and low-cost operation. It incorporates numerous technical improvements over laboratory models of industrial television systems which RCA has demonstrated since 1947 and which have been supplied in small quantities to the government and some manufacturers, utilities, and research centers.

The new camera contains only three tubes, one of which is the new Vidicon photoconductive camera tube. Although only 1 inch in diameter and 6 inches long, the Vidicon is almost as sensitive as the studio-type Orthicon tube. The camera is designed to use standard 16-millimeter motion picture camera lenses with a "C" mount, allowing for a wide choice of lenses for specific applications.

The new equipment is designed to maintain continuous visual checks on numerous operations in industry and research laboratories that are too remote, inaccessible, or hazardous for direct viewing by human observers.

The test demonstrations pointed out new uses for industrial television in railroading. Recording serial numbers of freight cars from fixed locations and co-ordinating movements of cars and switching engines were accomplished successfully during the tests.

The entire equipment consists of only two units: a camera about the size of a 16-millimeter movie camera and a combination monitor, power supply, and control unit housed in a single portable case smaller than a home table model television set. The picture picked up by the camera is transmitted to the monitor's 10-inch viewing screen over a length of 18-conductor camera cable, 0.625 inch in diameter. Extra lengths of cable are supplied for the equipment on special order.

Whereas a broadcast-type television camera chain employs more than 60 vacuum tubes, the entire *1TV-5* system uses only 22. The monitor-power supply-control unit contains all the controls for operation of the chain. These include controls for picture brightness and contrast, beam intensity, electronic focus, and optical focus. Once the system has been set up, all necessary adjustments can be made with only two knobs.

With the new industrial television chain, pictures of high quality can be obtained without excessive illumination. Scanning frequencies are 525 lines, 30 fields, 60 frames, interlaced, per second, the same as those of standard broadcast television. Home television sets can be used with the system as auxiliary viewers. The equipment also can be operated with microwave transmission from camera to receiver over extended distances.

This lightweight 2-unit chain operates from an ordinary 115-volt 60-cycle power supply, and is completely self-contained. Power consumption of the entire system is only 230 watts. Equipment designed for operation from a 50-cycle supply is available on special order. The camera is 10$^1/_2$ inches long, 5 inches high, and 3$^1/_2$ inches wide, and weighs 7$^1/_2$ pounds. The monitor-power supply-control unit weighs 70 pounds and is 20 inches long, 15$^1/_2$ inches high, and 13 inches wide.

Senior Reviewers Committee Increased to Six by AEC

The United States Atomic Energy Commission (AEC) Committee of Senior Reviewers has been increased from four to six members to meet the expanding scope of the AEC's technical activities, including engineering. The committee was originally established 6 years ago to advise the Commission on the classification and declassification of scientific and technical information.

The members of the former committee recommended that action and offered their resignations so that a reconstituted committee could be organized. Two members of the former committee were appointed to the new committee and four new members have been appointed. Membership will be for 5-year terms.

The new committee members are: Dr. R. H. Crist, Director of Physical Research, Carbide and Carbon Chemicals Company Plant, Charleston, W. Va.; Dr. J. R. Richardson, Associate Professor of Physics, University of California at Los Angeles; Dr. Thomas B. Drew, Head of the Department of Chemical Engineering, Columbia University, New York, N. Y.; and Dr. John P. Howe, Head of the Metals Division, Knolls Atomic Power Laboratory, Schenectady, N. Y.

The members of the former committee who have been reappointed are: Dr. Warren C. Johnson, Associate Dean of the Physical Sciences, University of Chicago (Ill.); and Dr. J. M. B. Kellogg, Division Leader, Los Alamos (N. Mex.) Scientific Laboratory.

Goodyear Selected to Operate Ohio Uranium Plant by AEC

The Atomic Energy Commission (AEC) has announced the selection of the Goodyear Tire and Rubber Company, of Akron, Ohio, as operating contractor for its uranium-235 production plant soon to be built in Pike County, Ohio, between Portsmouth and Chillicothe.

When the $1,219,000,000 facility is completed in about 4 years, the Goodyear Company will be the principal employer there with a permanent working force of about 4,000 persons.

Goodyear will put individual units of the gaseous diffusion plant into operation as they are completed. All operating employees will undergo an extensive training program so that some hiring of permanent personnel probably will begin early next year.

In assuming this operation, Goodyear officials will work closely with Union Carbide and Carbon Corporation, operating contractor for the gaseous diffusion plants at Oak Ridge, Tenn., and Paducah, Ky. The Carbide Company also will assist in the training of key personnel employed by Goodyear.

Water Purification Unit Treats 2,400 Gallons an Hour

The United States Army's new truck-mounted electric water purification unit is capable of treating, clarifying, filtering, purifying, and distributing 2,400 gallons of water an hour in temperatures as low as 40 degrees below zero.

The unit, which can easily be transported on a cargo-type plane to combat zones, contains several inventions and numerous developments resulting from years of basic and applied research at the Engineer Research and Development Laboratories, Fort Belvoir, Va.

Heart of the unit is an ultrahigh-rate solids contact water conditioner called an erdlator. This device is connected in series with diatomite filters, and the combination not only removes silt and destroys bacteria, but also provides positive physical barriers to the passage of harmful organisms.

Polluted water can be pumped into the unit and chemically and physically treated and discharged as potable water in approximately 20 minutes.

Only one man is required to operate the unit and it can be put into operation by three men in less than 90 minutes after arrival at a selected site. Equipped with its own power source, it can be operated in total blackout. The only noise audible is from the engine driving the generator.

American Engineers to Aid Japan in Setting Up Power Survey

Two American engineers, F. Douglas Campbell (M '45) of The Detroit Edison Company and Leroy L. Hinckley of Pacific Gas and Electric Company, have arrived in Tokyo, Japan, to assist the Japanese electric power industry in setting up an electric power survey procedure similar to that carried on in the United States by the Edison Electric Institute. The visit is being made at the invitation of the Japanese Government and was proposed by Joseph M. Dodge, consultant to the Secretary of State on Economic and Financial Matters affecting Japan.

Both Mr. Campbell and Mr. Hinckley, are members of the Edison Electric Institute's Electric Power Survey Committee, which is composed of representatives of the electric power systems of the United States and of the country's principal manufacturers of heavy electric power equipment. Through its semiannual surveys the committee establishes up-to-date forecasts of electric power loads, the schedules of expansion of electric power facilities, the scheduled production of heavy power equipment, and the potential production ability. This information is of great importance in evaluating the manufacturing capacity required to meet the country's own needs and in determining that which is available for export trade.

Mr. Campbell spent several months in Europe in 1950 as Consultant for the Economic Co-operation Administration in establishing electric power surveys in the countries participating in the European Recovery Program. Mr. Hinckley, a specialist in methods of forecasting loads and system capability, has had broad experience in this field in California, where, as in Japan, there is considerable hydroelectric power.

The work to be carried out in Japan by Mr. Campbell and Mr. Hinckley will be chiefly with representatives of the electric power systems and the heavy equipment manufacturers and will have no direct relation to work being done there by other American engineers and consulting firms in the electrical field.

There are important international advantages in having comparable information among the free countries of the world concerning electric power and the availability of heavy power equipment. Corresponding information with respect to Japan will further these advantages.

New X-Ray Machine Detects Wheat Weevils

The destructive wheat weevil now is being detected by X rays. The bug, which sometimes resides inside a grain of wheat, has been brought out into the open by the development of a new grain inspection X-ray unit by the Westinghouse Electric Corporation.

Called GIXU by its makers, the unit was unveiled at the National Association of Grain and Feed Dealers Convention in Minneapolis, Minn., in September.

The machine offers a rapid method of insuring that wheat meets Food and Drug

Administration standards. In fact, all the features of the machine were developed with the aim of making a fast inspection possible.

GIXU can accomplish a complete test in approximately 15 minutes, while the best recorded time for other models is 20 minutes. In making the test about a handful of wheat (a carload is judged on the insect content of a mere 100 grams) is placed in a tray and radiographed. After developing, the picture is read for the telltale black surface specks that result from newly laid weevil eggs. If the eggs have hatched and the larva has burrowed inside the shell, the tunnel and body easily are detected by the different shadings of the wheat grain.

GIXU permits the inspector to see the entire development of the weevil from egg to adult. A carload of wheat is rejected as unfit for human consumption if more than a small established minimum of insects is detected.

Principal among the features of the machine which will make the grain inspectors' job easier is the high rating of the X-ray tube which gives a picture in half the normal time for such machines. The compactness of the unit enables it to be carried to different inspection points when necessary.

Scintillation Counter Tests Quality of Asphalt

A scintillation counter is an important part of a new test method aimed at producing better highways with the aid of atomic radiation.

In the laboratories of The Atlantic Refining Company, Philadelphia, Pa., manufacturers of paving asphalt, typical road stone is soaked in radioactive calcium chloride and dried. It is then coated evenly with asphalt, which may contain additives to improve the adhesive characteristics, and the mixture is covered with water for a specified period of time.

If the asphalt separates from the stones, the radioactive calcium chloride dissolves into the water. After evaporation, the radioactivity of the residue is measured with the scintillation counter. A correlation between the radioactivity count and previously prepared charts tells the Atlantic engineers the quality and adhesive characteristics of the asphalt.

American and Italian Companies to Manufacture Radar Jointly

The United States Navy has entered into a contract with the Raytheon Manufacturing Company, Waltham, Mass., and Microlambda, Rome, Italy, covering the manufacture of radar in Italy under the North Atlantic Treaty Organization (NATO) "off-shore procurement" program.

Under the terms of this agreement, which is the first of its kind to be formulated, Raytheon will provide engineering and manufacturing assistance and "know-how" to Microlambda which will produce the radars in a newly constructed modern plant near Naples. To the extent feasible Microlambda will procure and manufacture the necessary parts and materials from NATO countries.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Shortage of Engineers

To the Editor:

The AIEE has recently published a number of articles describing a shortage of engineers, which is seen now and anticipated for the future. Estimates of various agencies are quoted to indicate a large number of unfilled engineering jobs. This is hard to believe. The period between January 1, 1949, and July 1, 1950, was as close an approximation as we can expect to operation of our economy at full civilian capacity. During that period engineering jobs were hard to get, and plenty of engineers worked at nontechnical jobs. A good demonstration is the employment advertising in *Electrical Engineering* during that time. Now, of course, there are many jobs open, and *Electrical Engineering* has pages of employment advertisements. However, this is clearly a rearmament phenomenon; all of the big advertisers are rapidly building new organizations to handle their new military contracts. These openings cannot honestly be called permanent, and they do not justify a high school senior in choosing engineering as a career. And even armament will not maintain its present rate of hiring, even if the size of the projects remains the same.

If the appropriations dry up, if Russia smiles for a few years, the openings will close down. All of us in the armament industry have seen it before. Even if the military requirements remain fixed, it is obvious to most engineers in the industry that they can be satisfied with many fewer engineers than are now employed. It is unthinkable that the present inefficiencies should persist into the steady state. Nearly every new development is done by three or four contractors, and many contractors are convinced that all inadequacies in facilities, leadership, and ideas can be remedied by hiring more engineers on cost-plus. Many engineers to whom I have listened think we have a technological WPA, a way of injecting money into the economy in which direct returns are not important. It certainly seems that way. If so, it is a little different from a "shortage" of engineers.

Another way of looking at the present demand for engineers is to look at the pay offered. The usual relations should be expected between supply and demand. Most of the engineers in my organization make less than the union rate for electricians. They all make less than a successful provision merchant or milk driver. They do not live in prosperous neighborhoods, nor do they, in general, drive new cars. If our society needs their services urgently, it has not said so loud and clear.

The articles about the shortage are generally written by men employing large number of engineers, or engineering educators. Both of these groups have an economic advantage in the introduction into the job market of a large number of new engineers. This viewpoint is certainly detrimental to the interests of the men already in the field, and to the potential entrants. It does not seem fair for *Electrical Engineering* to present their viewpoints exclusively. I think *Electrical Engineering* should do all it can for the working engineer, and present these facts to the public.

LEE CAHN (AM '49)

(Downey, Calif.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ANNUAL REVIEW OF NUCLEAR SCIENCE Volume 1. Annual Reviews, Inc., Stanford, Calif., 1952. 645 pages, charts, tables, graphs, 9 by $6^{1}/_{4}$ inches, bound. $6.50. This is the first of a series designed essentially to survey the literature in the field. The authors of the several papers, dealing with a wide range of topics from meson physics to low-temperature phenomena and radioisotope uses, were required not only to cover the outstanding developments, but also to provide sufficient background material to make possible a critical appraisal of the current status of the subject matter. Reference is made throughout each article to its accompanying bibliography.

AUTOMATIC AND MANUAL CONTROL. Edited by A. Tustin. Conference on Automatic Control organized by the Department of Scientific and Industrial Research. Academic Press Inc., 125 East 23d Street, New York 10, N. Y., 1952. 584 pages, diagrams, graphs, charts, tables, 10 × $7^{1}/_{2}$ inches, bound. $10. This collection of conference papers is intended to provide a work of reference for those engaged in the design of control equipment, and to serve as a source of information for those with some knowledge of basic principles who wish to extend their knowledge in various more specialized directions. The major sections deal with the general theory of servomechanisms, feedback control, and so forth; with process control analysis; with the aspects designated as nonlinear problems; and with systems working on intermittent data and step-by-step servos. Special papers deal with educational problems, the human operator, and particular devices and applications including analogues.

CALCULUS OF VARIATIONS. With Applications to Physics and Engineering. By Robert Weinstock. McGraw-Hill Book Company Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 326 pages, $9^{1}/_{2}$ by $6^{1}/_{4}$ inches, bound. $6.50. Following a brief treatment of the classical elementary problems, this book provides sections involving the role of the calculus of variations in particle dynamics, geometrical optics, quantum mechanics, elasticity, electrostatics, and in the eigenvalue problems associated with the vibrating string and vibrating membrane. Techniques and underlying ideas are emphasized.

DIRECT-CURRENT MACHINERY. By Charles S. Siskind, McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 319 pages, diagrams, illustrations, tables, charts, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6. Assuming a background of the elementary principles of electric and magnetic circuits, the subject matter progresses through the fundamental theories of generators and motor operation, the uses of auxiliary and control equipment, the numerous constructions and applications of present-day d-c machines and devices, and the development of special machines. The object is to provide a fundamental, logical text for a 1-semester course.

ELECTRICAL CODE DIAGRAMS. Volume I. By B. Z. Segall. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 343 pages, charts, tables, diagrams, $11^{1}/_{4}$ by $8^{1}/_{2}$ inches, bound. $12.50. This first volume of a 2-volume set covers wiring design and protection and wiring methods and materials. Intended as a practical aid for doing work in accordance with the National Electrical Code, it shows diagrammatically one or more illustrations for each code rule. Supplementary text is given where it is helpful. This background material demonstrates the reasons for the rules. Both practical and theoretical material is given. The second volume will deal with general equipment, with special occupancies, equipment, and conditions, and with communication systems.

FAULT CALCULATIONS. By C. H. W. Lackey. Oliver and Boyd Ltd., Edinburgh, Scotland, 1951. 296 pages, diagrams, illustrations, charts, 9 by 6 inches, bound. 30s. The elements of various calculation techniques are set out in the first part of the book, particular stress being laid on their practical application. Another section outlines the nature of the impedances of machines, transformers, overhead lines and cables, gives typical values, and includes tables and nomograms so that particular impedances may be calculated from known physical dimensions. A final chapter is included on the subject of fault calculators and network analysers. The book is intended both as a text for students and a reference work for power-system engineers.

IMPERFECTIONS IN NEARLY PERFECT CRYSTALS. Symposium held at Pocono Manor, October 12–14, 1950. W. Shockley, editorial committee chairman. Sponsored by The Committee on Solids, Division of Physical Sciences, National Research Council. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1952. 490 pages, illustrations, tables, charts, graphs, $8^{1}/_{2}$ by $5^{3}/_{4}$ inches, bound. $7.50. Seventeen papers by authorities in the field deal with a variety of topics connected with crystal structure from both the experimental and theoretical viewpoints. They have been broadly classified under the following headings: on the nature of imperfections in nearly perfect crystals; the role of imperfections in deformation; diffusion and related phenomena; on the properties and effects of external and internal surfaces of crystals.

INDUSTRIAL WASTE TREATMENT. By Edmund B. Besselievre. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 391 pages, illustrations, diagrams, tables, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7. Beginning with discussion of the nature, cause, and general aspects of an industrial waste problem, the author first establishes basic methods of approach to a solution. Technical subjects covered include sampling and analysis of wastes, pollutional effects, methods of waste treatment, handling methods, and the recovery of usable materials. Legal factors and economic aspects are thoroughly covered.

INSTRUMENT ENGINEERING. Volume I: Methods for Describing the Situations of Instrument Engineering. By Charles Stark Draper, Walter McKay, and Sidney Lees. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 269 pages, charts, graphs, tables, diagrams, $11^{1}/_{4}$ by 9 inches, bound. $6. The complete 3-volume set is to present a generalized method of attack on the problems of measurement and control as a comprehensive reference for the practicing engineer or an extensive textbook. Volume I develops a system of concepts, notations, diagrams, and mathematical forms for describing the performance of physical devices and variations in physical quantities. It provides a description of the physical circumstances under consideration by means of diagrams, mathematical forms curves, and numerical data.

MACHINERY AND EQUIPMENT FOR RUBBER AND PLASTICS. Volume I: Primary Machinery and Equipment. By Robert G. Seaman, editor, and Arthur M. Merrill, associate editor, *India Rubber World*, 386 Fourth Avenue, New York 16, N. Y., 1952. 804 pages, tables, diagrams, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $15. The complete 2-volume set is intended to provide the rubber and plastics industries with classified information for their manufacturing operations on what machines are available for use, how they work in the manufacture of the finished products, and where they may be obtained. This first volume covers primary equipment: mills, mixers, calenders, extruders, presses, and so on, and the special machines used for the manufacture of tires and tubes, hose and belting, footwear, wire and cable, latex goods, and plastics film and sheeting. Each classified section begins with a general summary article, written by a specialist, which describes procedures and operations as well as the machinery involved. The second volume is to cover supplementary machinery and equipment.

THE MEASUREMENT AND CONTROL OF TEMPERATURES IN INDUSTRY. By R. Royds. Chemical Publishing Company, Inc., 212 Fifth Avenue, New York, N. Y., 1952. 260 pages, charts, diagrams, tables, illustrations, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $5. Covers the latest developments for maintaining high thermal efficiency as utilized in a wide variety of industries. The various methods and equipment available for the measurement of temperatures in each particular range are discussed. Considerable space is devoted to the standardization and automatic control of temperatures. Attention is given to improving product quality, increasing production rates, and the saving of fuel and labor by the application of automatic temperature controls.

CONTROLLERS FOR ELECTRIC MOTORS. A Treatise on the Modern Motor Controller With Typical Applications to the Industries. By Henry Duvall James and Lewis Edwin Markle. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y., second edition, 1952. 426 pages, diagrams, graphs, illustrations, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound, $7. The construction, performance, and operation of all types of commercial motor controls in general use are described. Protective devices are explained in detail and brief instructions for installation and maintenance are included. Special control systems, such as for elevators, steel mills, and so forth, are not considered. The book is intended for technical students as well as for operating men and application engineers, and only a limited knowledge of electric motors is required. The revision includes new developments such as the magnetic amplifier.

ELECTRIC MACHINERY. An Integrated Treatment of A-C and D-C Machines. By A. E. Fitzgerald and Charles Kingsley, Jr. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 702 pages, tables, graphs, diagrams, illustrations, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound, $8.50. Intended for undergraduate machinery courses in electrical engineering, this text presents the theory in a manner which highlights the basic principles common to all rotating electric machines, as well as to a wide variety of electromechanical energy-conversion devices. This basic theory is then applied to d-c, synchronous, polyphase induction, and single-phase machines, together with amplidynes, Rototrols, and Selsyns. The book concludes with introductions to machine transients and the dynamics of electromechanical systems. There is a final chapter on transformers.

ELECTRONIC ANALOG COMPUTERS. By Granino A. Korn and Theresa M. Korn. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 378 pages, illustrations, diagrams, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound, $7. Following an introductory chapter, the book describes practical setup procedures and the application of d-c analogue computers to representative practical problems. The theory, design, and operation of linear computing elements, amplifier circuits, and control circuits are covered in a practical manner. Developments in the field of analogue multiplication and function generation are discussed, and the design and construction of complete computer installations are given for various applications in industry and science. The book constitutes a manual which is intended to promote the effective operation of d-c analogue computers by anyone whose mathematical background covers elementary differential equations.

ELECTRONIC MEASUREMENTS. By Frederick Emmons Terman and Joseph Mayo Pettit. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y., second edition, 1952. 707 pages, diagrams, graphs, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound, $10. The aim of this book is to provide a comprehensive engineering discussion of the measuring problems commonly encountered by radio or electronics engineers. It is intended to serve the practicing engineer as a compendium of information on measuring techniques and equipment, and the student as a textbook on general measuring principles. A revision of the formerly titled "Measurements in Radio Engineering," the present volume is nearly doubled in size and covers a much wider range including television, radar and other pulsed systems, microwaves, and so forth.

ELECTRONICS FOR COMMUNICATION ENGINEERS. By John Markus and Vin Zeluff. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 610 pages, charts, diagrams, tables, graphs, 11 by $8^{3}/_{4}$ inches, bound, $10. Some 250 selected articles from the magazine *Electronics* compose this volume, arranged logically within 16 subject groups as follows: amplifiers, antennas, audio, cathode-ray tubes, components, electronic music, filters, measurements, microwaves, oscillators, power supplies, propagation, pulses, receivers, transmission lines, transmitters. Essential design information is provided in the field of radio communication, broadcasting, television, and radar. Author and subject indexes are provided.

GRAPHIC METHODS FOR SOLVING PROBLEMS. By Frank A. Heacock, Professor of Graphics, Princeton University, 1952. 113 pages, charts, diagrams, graphs, 11 by $8^{1}/_{2}$ inches, paper. Available from Princeton University Store, Princeton, N. J., $1.90 postpaid. This book is intended as a reading guide to recent literature on graphic methods as applied to the solution of technical problems in various fields of engineering, science, and industry. Explanatory text precedes the bibliography in each of the eight sections: simple graphs and charts, the hydrograph, geometric diagrams, network charts, vectors and mechanics, descriptive geometry, nomographs, graphic analysis. Over 600 references are given, from 1937 to 1950, with a brief abstract or annotation in each case.

HANDBUCH DES WASSERBAUES. By Armin Schoklitsch. Volume II. Springer-Verlag, Vienna, Austria, second edition, 1952. 593 pages, illustrations diagrams, charts, tables, 11 by 8 inches, bound, $37. Continuing the revision of this classic work, the first edition of which was translated into English some 15 years ago, this second volume covers in detail the hydraulic structures connected with dams and outlet works, hydraulic power stations, drainage and irrigation, river and canal engineering. Over 2,000 section drawings and photographs illustrate the text. Volume I, issued in 1951, covered hydrology and hydraulics, water-supply engineering, sewerage, and sewerage disposal. The two volumes comprise a complete treatise on the subject, and furnish as well, by means of literature references, a guide to a wide range of specialized aspects and structures.

TABLES OF COULOMB WAVE FUNCTIONS. Volume I. (Applied Mathematics Series 17.) National Bureau of Standards, General Post Office, Washington 25, D. C., 1952. 141 pages, tables, $10^{1}/_{2}$ by 8 inches, bound. $2. Continuing this series of publications from the National Applied Mathematics Laboratories, the present volume presents a group of special functions of particular use in the fields of nuclear physics and astrophysics. An extensive explanatory introduction and a list of literature references are also included.

THEORY OF SUPERCONDUCTIVITY. By M. von Laue. Translated by Lothar Meyer and William Band. Academic Press Inc., 125 East 23d Street, New York 10, N. Y., 1952. 140 pages, charts, graphs, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $4. The aim of this book is to provide a more effective representation of the phenomena of superconductivity by extending Maxwell's electrodynamics along the lines first suggested by Fritz and Heinz London. Following a statement of fundamental facts, specific phenomena are dealt with in a more detailed manner. The final chapter presents a nonlinear extension of the theory.

THE PETROLEUM DICTIONARY. By Lalia Phipps Boone. University of Oklahoma Press, Norman, Okla., 1952. 338 pages, $8^{1}/_{2}$ by 6 inches, bound. \$5. This compilation contains more than 6,000 words and expressions—both technical and nontechnical—which comprise the everyday language employed in the four major branches of the industry: exploration, production, pipe-lining, and refining. To these have been added names (and nicknames) of fields, wells, persons, and geological formations, as well as slang and specialized expressions native to the oil industry. A detailed introductory discussion of the "language of the oil field" precedes the main dictionary section.

PRACTICAL INDUSTRIAL ELECTRONICS. By F. A. Annett. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 381 pages, diagrams, charts, $9^{1}/_{2}$ by $6^{1}/_{4}$ inches, bound, \$5.50. Written expressly for operating engineers, electricians, and others with little previous training in the subject, this book deals in a simple way with the electron itself, the various tubes, the fundamental circuits, and the more complex circuits and performance of many different control devices. Precise operational sequences are given for a variety of applications.

THE REFRIGERATING DATA BOOK. Refrigeration Applications Volume. American Society of Refrigerating Engineers, 40 West 40th Street, New York 18, N. Y., third edition, 1951. 894 plus 224 pages, illustrations, tables, diagrams, charts, $9^{1}/_{2}$ by $6^{1}/_{2}$ inches, bound. \$6. Supplementing the basic volume which deals with refrigeration theory and design engineering, this manual covers the use of the science and art of refrigeration and the application of refrigerating machinery and associated equipment to solve the user's needs. Eight major sections are provided: frozen foods; cold storage practice; refrigeration in food manufacture; refrigerated food distribution; low-temperature applications; industrial applications; comfort air conditioning; industrial air conditioning. A buyers' guide of refrigeration equipment is included.

ULTRASONICS. (Chemical Engineering Progress Symposium Series, Number 1, volume 47.) Edited by F. J. Van Antwerpen. American Institute of Chemical Engineers, 120 East 41st Street, New York 17, N. Y., 1951. 87 pages, graphs, illustrations, tables, diagrams, 11 by $8^{1}/_{4}$ inches, paper. First of a series intended to provide the chemical engineer with basic studies on various phases of his field, this volume presents ten papers by authorities on the subject. Among the topics treated are material testing and gauging, basic principles of the application of sonic and ultrasonic energy including physical and economic limitations for industrial processes, and basic design considerations of the equipment for generating ultrasonic energy.

WORLD POPULATION AND FUTURE RESOURCES. The Proceedings of the Second Centennial Academic Conference of Northwestern University. Edited by Paul K. Hatt. American Book Company, 88 Lexington Avenue, New York 16, N. Y., 1951. 262 pages, graphs, $8^{1}/_{2}$ by $5^{3}/_{4}$ inches, bound. \$3.50. Twenty papers by specialists in a wide range of fields are broadly classified as follows: the population factor; food resources; material resources of industry; energy resources. In addition to a logical presentation of the problem posed by our expanding world population, certain technological aspects of the problem are emphasized in separate papers: mineral resources and exploitation; the future of structural materials; new products; liquid fuels for the future; solar and atomic energy in the world economy; food technology.

LIFE TESTS FOR DIRECT CURRENT CAPACITORS. CORROSION AND BREAKDOWN IN DIRECT CURRENT CAPACITORS. By H. Kromann Kristensen. Transactions of the Danish Academy of Technical Sciences, Numbers 5 and 6. Copenhagen, Denmark, 1949. 64 pages, 52 pages, diagrams, illustrations, tables, charts, 10 by $6^{3}/_{4}$ inches, paper. Kr. 4.50, Kr. 6.00. The specialized tests described and analyzed in these two publications were conducted in conjunction with a large program covering the testing and approval of electrical material. The capacitors used and the conduct of the tests under specified conditions are described, with detailed statistical information in the case of the life tests. In the breakdown tests service conditions were imitated, and conclusions are drawn on a basis of the results.

PROCEEDINGS OF THE NATIONAL ELECTRONICS CONFERENCE. Volume VII. October 22–24, 1951. National Electronics Conference, Inc., 852 East 83d Street, Chicago 19, Ill., 1952. 607 pages, illustrations, diagrams, tables, graphs, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches bound. \$5. As in the previous volumes, the 70 or 80 papers presented are grouped in classified sections under the following headings: servo theory and distance measurement; electron tube developments; information theory; audio systems; signal detection; high-frequency measurements; analogue computers; application of magnetic amplifiers; circuit analysis; high-frequency electron tubes; industrial inspection and measurement; medical applications; industrial applications; television; magnetic amplifiers; components, measurement, and assembly; microwaves and propagation.

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THE RADIO AMATEUR'S HANDBOOK. By the Headquarters Staff of the American Radio Relay League, West Hartford, Conn., 29th edition, 1952. Various paging, tables, illustrations, diagrams, graphs, charts, $9^{1}/_{2}$ by $6^{1}/_{2}$ inches, paper. \$3. This standard manual of amateur radio communications covers the entire field from the fundamentals to the latest techniques in equipment design and construction. The considerable amount of technical data provided includes a comprehensive, up-to-date section of vacuum-tube data tables. The advertising section contains condensed manufacturers' catalogues. As usual, the new edition has been revised to conform to current practice.

COLOR IN BUSINESS, SCIENCE, AND INDUSTRY. By Deane B. Judd. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 401 pages, tables, graphs, diagrams, charts, $9^{1}/_{4}$ by 6 inches, bound. \$6.50. The importance of color as a standard of value of many products, as an incentive to purchase, and as a necessary attribute of a tremendous number of commercial and industrial items emphasizes the need for effective color inspection, measurement, and control. The author first shows how the eye works, then describes the tools and technics for color matching and measurement, color scales and standards, and finally discusses the physics and psychophysics of colorant layers. The book constitutes a detailed analytical treatment of the whole color problem, including many charts and diagrams and an extensive bibliography.

ELEKTROMOTOREN. Ihre Eigenschaften und ihre Verwendung für Antriebe. By W. Schuisky. Springer-Verlag, Vienna, Austria, 1951. 506 pages, diagrams, tables, charts, graphs, $9^{3}/_{4}$ by $6^{3}/_{4}$ inches, bound. \$11.40. This book on electric motors is intended for design and operating engineers as an aid to the planning, design, and evaluation of electrical drives. Special attention is given to pertinent characteristics from a purely motive power point of view; that is, those involved in such problems as starting, speed regulation, braking, efficiency, and the like, applicable to both normal and special purposes.

ENGINEERS AND IVORY TOWERS. Edited and arranged by Robert C. Goodpasture from published and unpublished papers of Hardy Cross. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1952. 141 pages, $8^{1}/_{4}$ by $5^{3}/_{4}$ inches, bound. \$3.50. A selection and compilation, in essay form, of the nontechnical writings and lectures of an eminent teacher and structural engineer. The content of the book reflects the author's opinions on the relationship of engineer and engineering to science and the humanities, touching on a wide range of subjects including education, graduate study, standardization, and the responsibilities and obligations of engineers.

MULTIMOTOR TRACTION FOR CRANES. By. Richard A. West. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W. C. 2, England, 1952. 84 pages, tables, diagrams, illustrations, 9 by $5^{1}/_{2}$ inches, bound. 21s. A companion volume to the author's "Electric Traction for Cranes," this book investigates the characteristics of motors and crane structures as a means for establishing methods of correct design. More than 30 drives are discussed. Series and parallel combinations of a-c and d-c motors are covered; also differential drives and the use and selection of servo and power selsyns. Extensive data are given on the inertia of high-speed parts in connection with wheel slip and braking.

RADIO ANTENNA ENGINEERING. By Edmund A. Laport. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., first edition, 1952. 563 pages, illustrations, tables, charts, diagrams, graphs, $9^{1}/_{4}$ by $6^{1}/_{2}$ inches, bound. \$9. Sufficient useful information is presented to enable nonspecialists to handle many of the ordinary problems of antenna design and construction. The book deals with antennas made of wires, masts, and towers with frequencies up to 30 megacycles. It includes some of the more advanced designs suggested by very-high-frequency and ultrahigh-frequency techniques. Receiving and transmitting antennas for point-to-point and ground-to-air communications, as well as for broadcasting, are covered. The book also considers operational requirements, propagation engineering, and system engineering

TRANSIENT ELECTRIC CURRENTS. (Electrical and Electronic Engineering Series.) By Hugh Hildreth Skilling. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., second edition, 1952. 361 pages, tables, charts, illustrations, diagrams, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. \$6. A presentation of basic principles in which the abstract mathematics have been restricted to a minimum. The first four chapters form the nucleus, covering inductance, capacitors, circuit equations, and the complete single circuit. The addition of chapters 5 and 6 completes a course on the treatment of networks of lumped parameters. The following chapters take up coupled resonant circuits, circuits with variable parameters, traveling waves, operational methods of analysis, and oscillographs. In the new edition a chapter has been added on the Laplace Transformation.

UNTERGRUNDBAHNEN UND IHRE EINSATZGRENZEN. By Rudolf Berger. Verlag von Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany, 1951. 99 pages, tables, charts, maps, $9^{1}/_{2}$ by $6^{3}/_{4}$ inches, paper. D.M. 9.50. This book on the economic planning and utilization of underground rapid transit discusses the factors involved in the establishment and extension of subway rapid-transit systems from both the technical and economic points of view. An analysis is made of the systems and their operation in 20 large cities, including a discussion of the lower and upper limits for subway rise and expansion. Brief descriptions and maps are appended.

THE WELDING OF NON-FERROUS METALS. By E. G. West. John Wiley and Sons Inc., 440 Fourth Avenue, New York 16, N. Y., 1951. 553 pages, illustrations, tables, diagrams, charts. $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. \$8.50. Combining both an insight into the metallurgical aspects of the subject and a practical treatment of the welding process, the author begins with a discussion of weldability and summaries of the fusion, resistance, and pressure welding processes. He then deals respectively, in a detailed manner, with the welding of aluminum and its alloys; magnesium alloys; copper, nickel, lead, zinc, and their alloys; low melting point metals; high melting point metals; and the precious metals.

AMERICAN UNIVERSITIES AND COLLEGES. Mary Irwin, editor. American Council on Education, 1785 Massachusetts Avenue, N.W., Washington 6, D. C., sixth edition, 1952. 1,105 pages, $9^{3}/_{4}$ by 7 inches, bound. \$10. Including the latest information, this book is an authoritative guide to accredited institutions of higher learning in the United States and its territories. In Part I there are concise but comprehensive descriptions of various aspects of American higher education. Part II supplies pertinent information about some 900 accredited institutions, now arranged alphabetically under the separate states. Further data are given in appendixes including Reserve Officers Training Corps data for each institution.

DIESEL ENGINE CATALOG. Volume 17, 1952. Rex W. Wadman, editor and publisher. Published and distributed by Diesel Engines, Inc., 816 N. La Cienega Boulevard, Los Angeles 46, Calif. 409 pages, illustrations, diagrams, charts, tables, $13^{3}/_{4}$ by $10^{1}/_{2}$ inches, bound. \$10. Presents detailed descriptions of American diesel engines, equipment, and accessories. All types are covered, including 2- and 4-cycle and dual fuel, for stationary, railroad locomotive, marine, and automotive use. A classified buyers' guide of engines and accessories is provided. As usual the new edition has been revised to include new designs developed during the intervening 12 months.

MECHANICS AND PROPERTIES OF MATTER. By Reginald J. Stephenson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1952. 371 pages, charts, graphs, tables, 9¹/₄ by 6 inches, bound. $6. This text stresses the physical concepts involved in mechanics while presenting as well the mathematical procedures involved. The importance of these concepts in the whole field of physics is demonstrated. Vectors and simplified vector analysis are used throughout the book to familiarize the student with their use. Illustrative problems occur in the text and practice problems accompany each chapter.

THE NATURE OF SOME OF OUR PHYSICAL CONCEPTS. By P. W. Bridgman. Philosophical Library, 15 East 40th Street, New York, N. Y., 1952. 64 pages, 9¹/₄ by 6¹/₄ inches, bound. $2.75. In the three lectures which compose this book the author aims at developing an awareness of the operational content of several important concepts, analyzing the operations into their instrumental and verbal components. The subject matter is as follows: concepts of the field and of empty space; concepts of thermodynamics; elementary electrical phenomena in massive conductors carrying electric currents.

PERSONNEL ADMINISTRATION. By William W. Waite. Ronald Press Company, 15 East 26th Street, New York, N. Y., 1952. 683 pages, tables, illustrations, charts, 9¹/₄ by 6¹/₄ inches, bound. $7. A restatement of the fundamental philosophies of personnel administration as they have evolved, demonstrating their application to current practical administrative methods and techniques. The problems of administration are discussed from the initial assembling of a work force through its efficient maintenance and interrelations with the staff. Extensive reading lists and selected questions for discussion are provided.

THE PHOTOGRAPHIC STUDY OF RAPID EVENTS. By W. Deryck Chesterman. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., 1951. 167 pages plus 32 pages, illustrations, diagrams, tables, charts, 8³/₄ by 5¹/₂ inches, bound. $5. This monograph deals with various techniques which may be employed and discusses the conditions of speed, lighting, repetition, and sensitivity which influence their choice. In addition to describing the equipment and characteristics of these techniques, the author also gives an account of some of the problems to which they have been applied, such as joint movements, high-speed machine tools, air-flow past projectiles, and the detonation of explosives.

PHYSIKALISCHES WORTERBUCH. By Wilhelm H. Westphal. Springer-Verlag, Reichpietschufer 20, Berlin W 35, Germany, 1952. Two volumes in one, 833 pages, 795 pages, illustrations, tables, graphs, charts, diagrams, 11 by 7¹/₂ inches, bound. DM 148.00. This highly useful reference work provides an encyclopedic treatment of the field of physics for the physicist who wants information outside his specialty and also for the engineer, metallurgist, chemist, biologist, or student. In addition to the regular physics topics, the book includes physical chemistry and also covers astrophysics, geophysics, and biophysics to some extent, as well as the mathematics which physicists and other scientific workers use. A considerable amount of technical data is given for quick reference and to make the book as self-contained as possible. There is a concise outline of the history of physics and birth and death dates are listed for nearly 900 physicists. Because of the rapid development in so many branches of physics since the last edition of Berliner and Scheel's "Physikalisches Handwörterbuch," this is virtually a new book rather than an enlarged edition of the former, although it fulfills the same purpose. Despite the fact that the book is entirely in German, the clarity and simplicity of presentation make it usable by anyone with a working knowledge of German.

PRACTICAL RADIOGRAPHY FOR INDUSTRY. By H. R. Clauser. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1952. 301 pages, tables, illustrations, charts, 9¹/₄ by 6¹/₄ inches, bound. $7.50. In order to provide concrete working details, information is given on setup procedures, exposure factors and techniques, radiograph quality, films and film processing, screens, and filters. Comprehensive coverage is given also to the interpretation of radiographs of castings and weldments and discussions of the applicable standards. X-ray generating equipment and fundamental radiographic principles are concisely treated, and separate chapters are devoted to special methods and miscellaneous applications such as thickness gauging and high-speed radiography.

THE RECORDING AND REPRODUCTION OF SOUND. By Oliver Read. Howard W. Sams and Company, Inc., 2201 East 46th Street, Indianapolis 5, Ind., second edition, revised and enlarged, 1952. 790 pages, tables, diagrams, illustrations, graphs, 9¹/₂ by 6¹/₄ inches, bound. $7.95. This book covers the essential requirements for a complete understanding of various aspects of sound and their relation to recording techniques and methods of reproduction. Theoretical considerations are fully explained and translated into practical descriptions, instructions, and advice. Recording and reproducing standards, a glossary of terms, a bibliography of magnetic recording, and other useful information are also included. Considerably enlarged, the book now covers the most recent developments in the field.

STARKSTROMTECHNIK. Part II. By E. v. Rziha. Verlag Von Wilhelm Ernst and Sohn, Berlin, Germany, 8th edition revised, 1952. 315 pages, diagrams, tables, graphs, charts, 8¹/₄ by 6 inches, paper. D.M. 24.00. Continuing a series on heavy-current engineering, this second volume deals with electric machines and transformers under the following headings: d-c machines, including the rotary converter; asynchronous machines; synchronous machines; a-c commutator machines; transformers. This new edition of a standard German reference work has undergone the customary revision to bring it up to date.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS SEVENTY-NINE THROUGH ONE HUNDRED THIRTY-FIVE. (The Annals of the Computation Laboratory of Harvard University, volume XIV) Harvard University Press, Cambridge, Mass., 1951. 614 pages, tables, 10³/₄ by 8 inches, bound. $8. This volume, the 12th of the "Bessel function" series, completes the tabulation of the family of functions $J_n(x)$ in the interval 0 x 100 for all integral n to at least ten decimal places. The present volume covers functions of the first kind for orders 79 through 135. Also included is a 15-place table of $J_n(n)$ for integral values of n from 0 to 100. These tables are intended for use in electrical and radio design work as well as for scientists and mathematicians.

LES TUBES ELECTRONIQUES A COMMANDE PAR MODULATION DE VITESSE. By R. Warnecke and P. Guénard. Gauthier-Villars, 55, Quai des Grands-Augustins, Paris, 6e, France, 1951. 792 pages, illustrations, diagrams, charts, graphs, 9¹/₂ by 6¹/₂ inches, bound. Ffrs. 7,000. The first two sections of this comprehensive work on klystrons cover electronic phenomena and general principles and the electric circuits of actual tubes. The principal types are described and considerable space is devoted to experimental results and technical data. There is a theoretical study of specialized aspects of the klystron concept, and also a practical treatment of problems in connection with their application. The book closes with a survey of possibilities of use and improvement.

TUNGSTEN. A Treatise on Its Metallurgy, Properties, and Applications. By Colin J. Smithels. Chapman and Hall Ltd., London, England, third edition, 1952. 326 pages, graphs, illustrations, tables, 9³/₄ by 6¹/₄ inches, bound. 75s. This standard reference work provides a comprehensive review of the metallurgy and properties of tungsten and its alloys, and of their industrial applications. The new edition is thoroughly revised in accordance with the developments of the last 15 years. Most of the chapters have been rewritten by experts, with Dr. Smithels assuming the general role of editor.

UNITED NATIONS STATISTICAL YEARBOOK. Prepared by the Statistical Office of the United Nations, Department of Economic Affairs, third issue, 1951. 616 pages, tables, 11¹/₂ by 9 inches, paper. Available from Columbia University Press, New York 27, N. Y. $6. Prepared by the Statistical Office of the United Nations Department of Economic Affairs, this compilation provides yearly statistics for the approximate period 1930–1950 for all countries for which figures were available. Subject fields covered include population, agriculture, mineral industries, manufactures, transport, commerce, and education. It is the aim of the yearbook to present for the various countries, over the period covered, continuous time series which are comparable internationally. All explanations and tabular designations, as well as the subject and country indexes, are printed in both English and French.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Bibliography of Technical Reports. Technical developments of value to American industry resulting from Government research projects are described in the July issue of the "Bibliography of Technical Reports." Among the specific developments described in this issue are a new high-speed cathode-ray tube; an X-ray method for quantitative determination of tetraethyl lead in aviation gasoline; a pilot plant for drying air by solid absorbents; a process for eliminating hydrogen embrittlement in steel; German techniques for making large forgings and light metal castings; a silver-iodide smoke generator for airplanes; and new ceramic and magnetic materials for the electronic industries. In all 178 reports are reviewed in this issue. Included are reports from state and foreign governments. 50¢ a copy. Available from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Program for Instrument Mechanic Training. Released by the National Office of the Instrument Society of America (ISA) is a detailed outline for operation of an Instrument Mechanic Training Program. It covers such aspects of a training program as selection of mechanic personnel, instructor's suggestions, physical equipment, reference books and films, and a detailed outline of training material according to subject. 60 pages. 75¢ for ISA members; $1.50 for nonmembers. Copies may be secured from the Instrument Society of America, 1319 Allegheny Avenue, Pittsburgh 33, Pa.

Guide to Tables of the Normal Probability Integral. Prepared by the National Bureau of Standards, this guide provides a ready reference for users of the normal probability tables. It includes the important sources of tables likely to be accessible in libraries and suggests some of the more recent publications which are of value. Of the guide's two main parts, the first gives the sources and essential characteristics of tables for the indicated types of segments of area under the normal curve. The second part consists of a bibliography of the sources referred to in the first part. 16 pages. 15¢. Order from Government Printing Office, Washington 25, D. C.

Survey of Theories of Luminescence. The possibility of better television tubes and fluorescent lamps is suggested in a survey by Navy researchers on the theories of luminescence. Major subjects covered by the survey are the mechanism of luminescence; activators; electron traps; and the efficiency of luminescent materials. 40 pages, including diagrams and graphs. $1.00 a copy. "A Survey of the Theoretical Aspects of the Luminescence of Inorganic Crystalline Solids," is available from the Office of Technical Services, United States Department of Commerce, Washington, D. C.

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INDUSTRIAL NOTES ....

General Electric Notes. Dr. A. F. Dickerson has retired as general manager of the Lighting and Rectifier Department after 42 years with the company. He will remain as a consultant to the department.

H. D. Middel has been named manager of the Utilities and General Services Department of the company's Hanford Works. He was formerly manager of plant engineering.

The home laundry equipment department headquarters has moved to Appliance Park, Louisville, Ky., from Bridgeport, Conn. It is the last of the five product departments of the major appliance division to move to Louisville.

Westinghouse News. Completion of all building construction for the new Westinghouse electronic tube plant and division headquarters at Elmira, N. Y., has been announced. Products to be manufactured in the new plant will include television picture tubes for home use and classified government use, and also transmitting, industrial, and special purpose tubes for both commercial and military applications.

A Research Laboratory has been established to serve all divisions of Westinghouse Air Brake Company and its subsidiary and affiliated companies. Thomas Meloy, president of Melpar, Inc., Alexandria, Va., has been appointed Director of Research, and the personnel and facilities of Melpar will be utilized by the new laboratory.

H. M. Detrick has been appointed manager of manufacturing for the Westinghouse Television-Radio Division plant at Metuchen, N. J.

Jensen Receives Award. Axel G. Jensen, director of television research, Bell Telephone Laboratories, Murray Hill, N. J., has been awarded the David Sarnoff Gold Medal in recognition of recent technical contributions to the art of television. The official presentation was made during the semiannual convention of the Society of Motion Picture and Television Engineers in Washington, D. C.

New AEC Office. A San Francisco Operations Office of the Atomic Energy Commission has been established. John Flaherty, assistant manager of the Chicago Operations Office, is manager of the new office. The San Francisco Area Office and the Berkeley Area Office are consolidated into the new operations office. It will be responsible for administration of contracts with the University of California for operation of the Radiation Laboratory at Berkeley; the California Research and Development Company for operation of facilities at Livermore; the North American Aviation, Inc., for developmental work being conducted at Downey, Calif.; and for other research and development contracts in the West Coast area. The new operations office will be established temporarily in quarters of the San Francisco Area Office at 200 Bush Street, San Francisco, Calif.

Owens-Corning Establishes New Sales Divisions. Creation of two new sales divisions within the General Products Division of Owens-Corning Fiberglas Corporation and appointment of managers for each have been announced. The new Battery and Process Products Division will be headed by Clifford L. Rowley, and activities of the newly established Air Conditioning Products Division will be managed by W. Whitney Kuenn.

Motorola Appointments. Dr. Robert S. Samuelson has been appointed chief engineer of the Motorola Research Laboratory at Phoenix, Ariz. He was formerly head of the Communications Research Section of the Laboratory.

H. A. Jones has been named manager, Technical Information Center of the Communications and Electronics Division.

Babcock and Wilcox Director. W. J. Thomas, general sales manager of the Tubular Products Division of the Babcock and Wilcox Company has been named to the board of directors of the division. Mr. Thomas, a graduate of Carnegie Institute of Technology, has been associated with the Babcock and Wilcox Company since 1932 and has been connected with the Tubular Products Division since 1941.

New Office for CEC Instruments. Consolidated Engineering Corporation has opened new and larger offices for its subsidiary company, CEC Instruments, Inc., at 285 Madison Avenue, New York, N. Y. Walter J. Beagan, New York and Northeastern United States Manager, will be in charge of the office.

Panascan Vice-President. Ralph A. Anderson has been appointed vice-president and chief engineer of Panascan, Inc., Chicago, Ill. He was formerly chief electrical engineer for Panellit, Inc., Chicago.

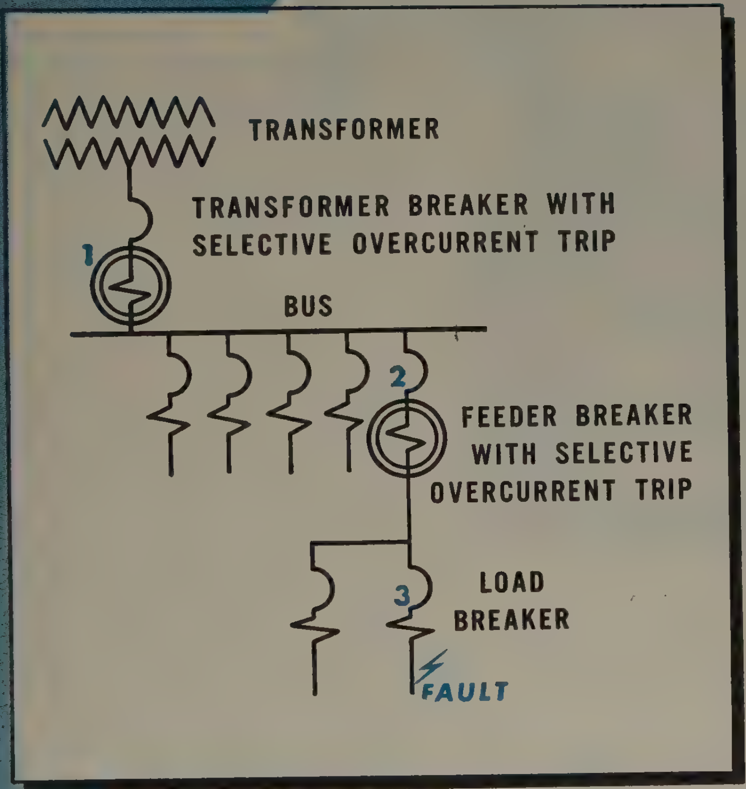
CBS-Hytron Moves. Hytron Radio and Electronics Company, a division of Columbia Broadcasting System, Inc., has moved from 76 Lafayette Street, Salem, Mass., to 100 Endicott Street, Danvers, Mass.

Leeds and Northrup Change of Address. The Philadelphia district sales office of Leeds and Northrup Company has moved from 4901 Stenton Avenue to 444 North 16th Street. The company's advertising department and training school also will occupy space at the new address.

Grove Joins Plaskon. James N. Grove has joined the New York Office of the Plaskon Division of the Libbey-Owens-Ford Glass Company as a sales representative for both Plaskon Polyester Resins and Libbey-Owens-Ford Fiber Glass to the plastics industry.

(*Continued on page 24A*)

COSTS LESS THAN YOU THINK


TRANSFORMER
TRANSFORMER BREAKER WITH SELECTIVE OVERCURRENT TRIP
1
BUS
2
FEEDER BREAKER WITH SELECTIVE OVERCURRENT TRIP
3
LOAD BREAKER
FAULT

HOW SELECTIVE TRIPPING WORKS

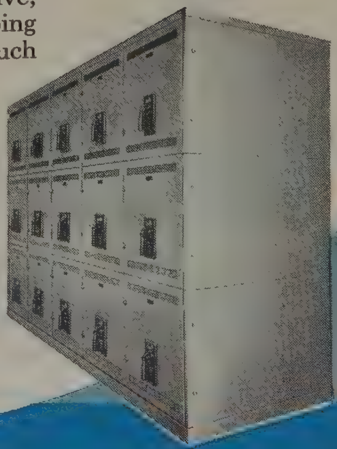
I-T-E circuit breakers, arranged in series, are *preset* to open in *definite sequence* (3, 2, 1 in diagram). If there is a sudden overcurrent or short circuit in any branch of the system, only the breaker (3) closest to the fault will open. Other breakers—other production machinery—in the system are unaffected.

ANOTHER I-T-E "FIRST"

Here is one more I-T-E "first"—another major I-T-E development to help industry protect production and save. Originally developed for the Navy during the War, the I-T-E Direct-Acting Selective Overcurrent Tripping Device has since been refined and perfected for industrial and utility use.

Call on I-T-E engineers—specialists in circuit breakers and switchgear—to see how positive, dependable I-T-E *Direct-Acting* Selective Tripping can protect your plant operation. See how much you can save.

For selection and application data on I-T-E large air circuit breakers, including selective tripping arrangements write for Catalog Section 1003 today. I-T-E Circuit Breaker Co., 19th and Hamilton Sts., Phila. 30, Pa.



LOW-VOLTAGE SWITCHGEAR

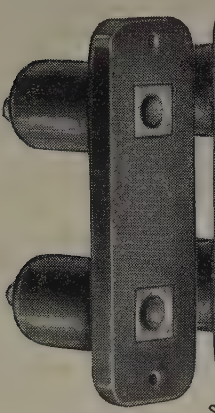
I-T-E CIRCUIT BREAKER CO. • 19th AND HAMILTON STS. • PHILADELPHIA 30, PA.

CANADIAN MFG. AND SALES: EASTERN POWER DEVICES, LTD., TORONTO • EXPORT SALES: PHILIPS EXPORT CORP., N. Y. 11, N. Y.

CANNON PLUGS for laboratory and switchboard

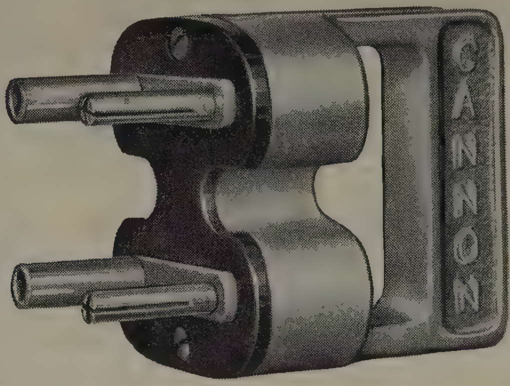
CSR Tandem Receptacle
CSP Plug

Here are a few examples of Cannon's Experimental Laboratory and Switchboard Connectors. They are used extensively throughout industry, public utilities, sound studios, broadcasting stations, college and university physics and chemistry laboratories, in AC network analyzers and electronic analog computers. They may be applied wherever quick disconnect switching and patch cord plugs are required. High grade materials are used throughout. Molded phenolic of high dielectric strength is used for insulation. Both pin and socket contacts are machined from solid brass. Some are silver plated. All are rated at 75 amps. Pin contacts are split for low loss seating in tapered bore sockets. Single contact fittings are supplied in either red or black phenolic to designate direct or alternating current circuits respectively. Two-contact and larger plugs have sand-blasted cast aluminum shells and handles with clear lacquer finish. Various combinations of pin and socket contacts are used as a polarizing guide. For further information write for Bulletin LS5-1951.

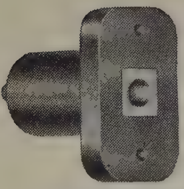


SDR Receptacle

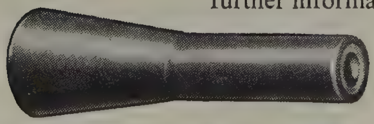
SDP Receptacle



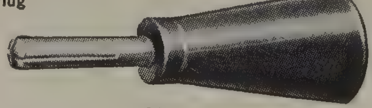
SWPR-4 Switching Plug having both pin and socket contacts



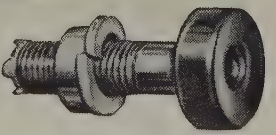
SR Receptacle



SCR Plug



SCP Plug



SRB Receptacle

CANNON ELECTRIC

Since 1915

Factories in Los Angeles, Toronto, New Haven, Benton Harbor. Representatives in principal cities. Address inquiries to Cannon Electric Company, Dept. K-117, P. O. Box 75, Lincoln Heights Station, Los Angeles 31, Calif.

(Continued from page 18A)

Philco Establishes Radio Division. Philco Corporation has established a separate Radio Division so that greater emphasis can be put on all phases of the company's activities in the home and automobile radio field. William H. Chaffee has been appointed vice-president of this division. The Television Division also has received separate divisional status.

Ohio Electric Appointment. Michael Fabbri has been appointed New England area electric motor sales engineer for The Ohio Electric Manufacturing Company. Mr. Fabbri will make his headquarters in Litchfield, Conn.

Humphrey Joins Mycalex. R. A. Humphrey has joined the Mycalex Corporation of America, Clifton, N. J., as engineer, research and development. He was formerly associated with the Electrotechnical Laboratory of the Bureau of Mines, Norris, Tenn.

NEW PRODUCTS • •

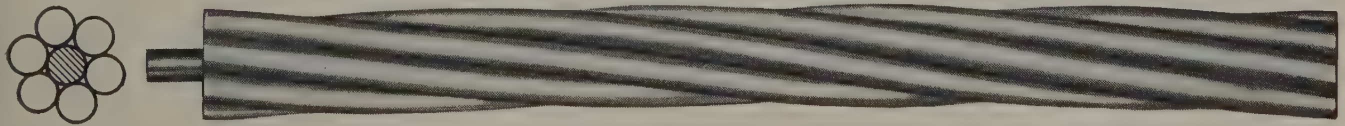
Cathode-Ray Chronograph. Accurate measurements of small time intervals between 1 millisecond and 95 milliseconds are possible with the new Model *H-91* Recurrent Sweep Chronograph manufactured by the Electronic Tube Corporation. The new cathode-ray chronograph may be used to measure the time interval between any electric impulses and is particularly useful for ballistic research where the clipped nature of the signal display gives an unmistakable pattern easily distinguishable from spurious noise pulses often picked up in the lines connecting the measuring coils and the indicating equipment. The *H-91* uses a temperature-controlled 1,000-cycle tuning fork to drive the scanning generators and to produce time pip markers. Accuracy of measurement is approximately ±10 microseconds. Further details on the new chronograph are available on letterhead request to Electronic Tube Corporation, 1200 East Mermaid Lane, Philadelphia 18, Pa.

Vidicon Camera Tube. The Tube Department of RCA Victor has announced its first commercial version of the Vidicon industrial television tube. Somewhat similar in size and shape to a cigar, but larger in diameter, the highly sensitive Vidicon tube is only one-tenth the size of a standard broadcast television camera tube. It measures only 1 inch in diameter and 6 inches in length. Utilizing a photoconductive layer as its light-sensitive element, the Vidicon has a sensitivity which permits the televising of scenes with 100 to 200 foot-candles of incident illumination. The photoconductive layer has a spectral response characteristic approaching that of the human eye. The

(Continued on page 32A)

The Swedes know how to make conductors . . .

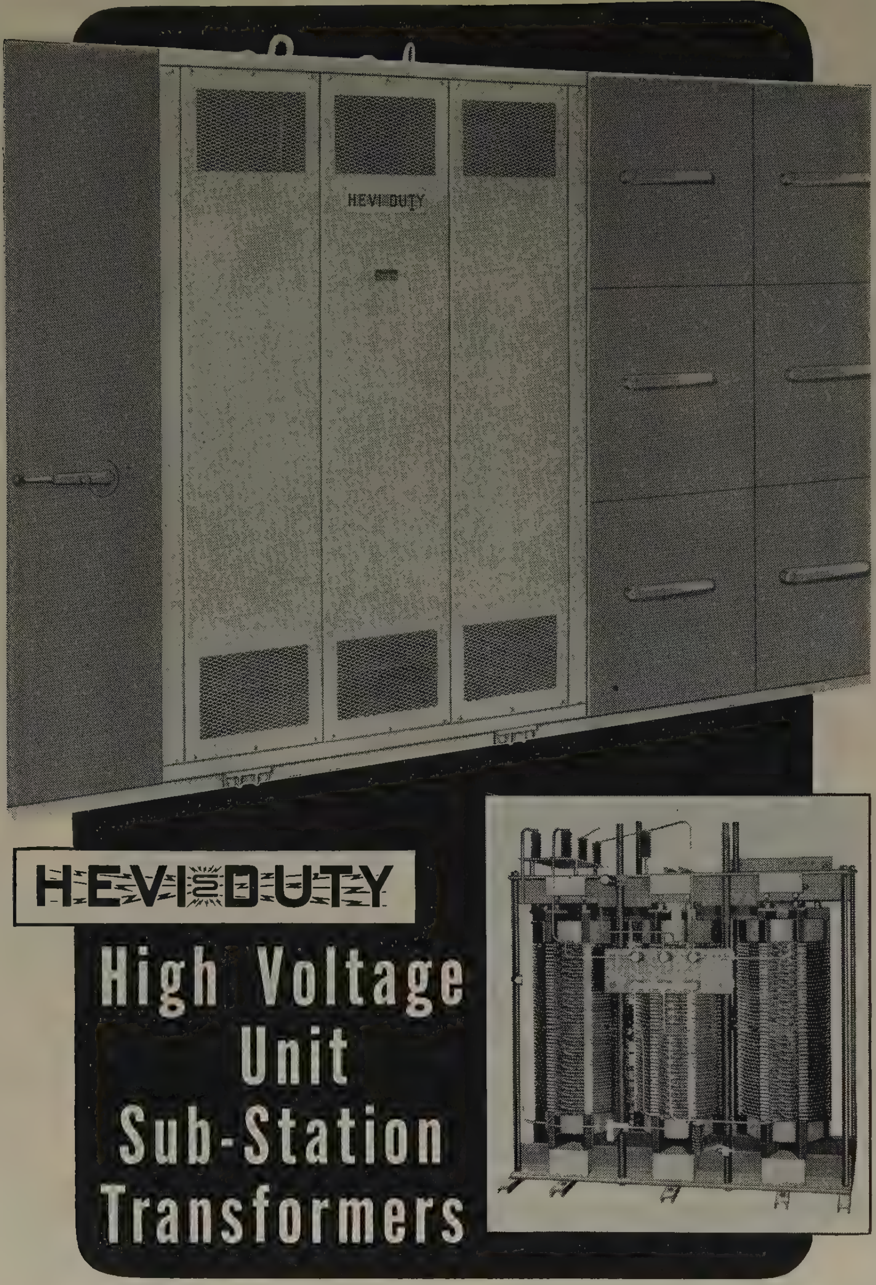
Installation of Feral Cable (Swedish-made ACSR) will—in round figures—be 40% cheaper than using copper cable. This is *one* of the reasons why Feral Cable is in demand all over the world. Other reasons are its low weight—30% lighter than copper cable—and its strength—30% stronger—which also adds to indirect savings in cost. The Svenska Metallverken Feral Cable plant is being enlarged in order to make it possible to meet the enormous demand for ACSR today. At the turn of the year 1952–53 the capacity is estimated to equal that of the world's largest manufacturers of ACSR.



***FERAL** ACSR *cable*

AB SVENSKA METALLVERKEN

SALES OFFICE: STOCKHOLM 16, SWEDEN



INCREASE EFFICIENCY OF LIGHTING AND POWER CIRCUITS BY SUPPLYING EQUIPMENT WITH THE CORRECT VOLTAGE

When you need electric power, you can count on Hevi Duty Dry Type Transformers for dependable service. These transformers are engineered to meet or exceed all the requirements necessary for long life.

Note the adequate core and coil blocking, high voltage insulators and well ventilated pancake type coils on the Type 31FH, 300 KVA, 13,200-208Y/120 volt, 60 cycle Transformer shown here.

Hevi Duty Dry Type Transformers can be supplied separately or as a Unit Sub-Station complete with primary and secondary switch gear according to your specifications.

Write for Bulletin HD-499.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers *Constant Current Regulators*

(*Continued from page 24A*)

tube provides 400-line resolution, employs magnetic focus and magnetic deflection, and operates with relatively low direct voltages. The size and location of the photoconductive layer permit a wide choice of commercially available lenses.

Cutoff Relay. A cutoff relay for providing end-point temperature control for processes requiring automatic shutdowns and manual resetting has been developed by Minneapolis-Honeywell's Industrial Division in Philadelphia, Pa. The relay operates with an electric temperature or pressure controller and a solenoid- or motor-operated valve. The relay has a capacity of 13 amperes at 115 volts, and 6.5 amperes at 230 volts.

Two New Insulating Resins. Two new epoxy-type insulating resins for complete encapsulation of electrical components where moisture resistance, high dielectric strength, and a tough protective coating are required have been announced by Minnesota Mining and Manufacturing Company, 900 Fauquier Street, St. Paul, Minn. Designated "Scotchcast" electrical insulating resins Number *1* and Number *2*, the new materials are expected to find wide use in the manufacture of coils, transformers, and other electrical components. "Scotchcast" electrical insulating resin Number *1* comes in a solid form together with a catalyst and is heated until liquified for pouring into the mold. The resin then sets and is cured at 250 degrees Fahrenheit in from 4 to 8 hours. "Scotchcast" Number *2* comes in a liquid form together with a hardener and can be poured into the mold and cured at room temperature in from 3 to 6 hours. Outstanding features of the new insulating resins are their 100-per-cent solids nature with no volatile products and a minimum of shrinkage upon curing; no chemical degradation within the operating range from −40 to 250 degrees Fahrenheit; resistance to acids, alkalies, solvents, and oils; and excellent adhesion to most metals, plastics and conductors. Technical data sheets are available from the manufacturer.

Waterproofed Push-Button Switch. A new push-button switch has been added to the line of waterproofed switches produced by Riverside Manufacturing and Electrical Supply Company, Dearborn, Mich. Developed to meet military specifications, the switch opens and closes electric circuits underwater, and is said to function perfectly from −65 to 165 degrees Fahrenheit, and withstand salt spray, shock, and vibration. The switch has a continuous rating of 10 amperes at 15 volts direct current, 30 volts direct current, or 125 volts alternating current. It is a single-throw 1-circuit switch, furnished either normally "open" or normally "closed." Complete information on this push-button switch and on waterproofed toggle switches up to 200

(*Continued on page 38A*)

THERE IS NO SUBSTITUTE FOR . . . MORE THAN 25 Years Experience

When Making Copper to Aluminum Connections Use

Cast Aluminum Connectors with Copper Liners

CAST ALUMINUM CONNECTOR OF OTHER MANUFACTURE

FOR CONTINUITY OF SERVICE *Be Sure* BY TEST COPPER LINERS ARE PROPERLY BONDED TO ALUMINUM CLAMPING MEMBERS.

Examination Discloses:

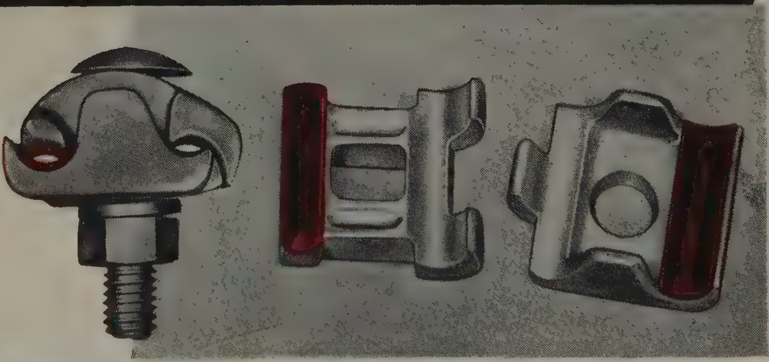
Poor Bond with voids allowing moisture and atmospheric contamination to enter between aluminum clamping member and copper liner causing electrolytic action and connector failure.

TEST:

COPPER LINERS EASILY PEELED LOOSE FROM ALUMINUM CLAMPING MEMBERS

ABW CAST ALUMINUM CONNECTOR

COPPER LINERS **SECURELY BONDED** TO ALUMINUM CLAMPING MEMBERS BY AN **EXCLUSIVE PROCESS WHICH PREVENTS VOIDS IN BOND.** YEARS OF SATISFACTORY CONNECTIONS CERTIFY THE USE OF THESE CONNECTORS.



Be Sure **Buy Aluminum Connectors, Clamps, Fittings and Accessories** backed with more than 25 *Years* of Electrical, Mechanical and Metallurgical Knowledge and Manufacturing Experience gained in Meeting and Maintaining the most Exacting Standards of the Electrical Industry.

OUR PRODUCTS ARE QUALITY CONTROLLED FROM INGOT TO FINISHED PRODUCT

CONSULT ONE OF OUR NEAREST EIGHTEEN REPRESENTATIVES OR CONTACT OUR MAIN OFFICE

ABW

ANDERSON BRASS WORKS, Inc.

Aluminum
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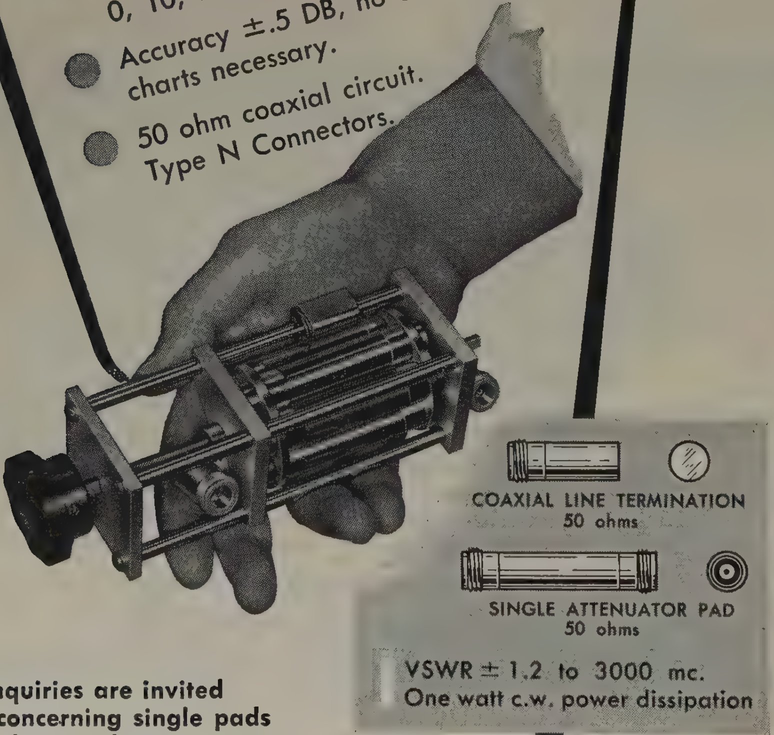
Bronze

SUBSTATION — TRANSMISSION — DISTRIBUTION

Power Connectors, Clamps, Fittings and Accessories

Precision
ATTENUATION
to 3000 mc!

- VSWR less than 1.2 at all frequencies to **3000 mc.**
- **TURRET ATTENUATOR** featuring **"Pull - Turn - Push"** action with 0, 10, 20, 30, 40, 50 DB steps.
- Accuracy ±.5 DB, no correction charts necessary.
- 50 ohm coaxial circuit. Type N Connectors.



Inquiries are invited concerning single pads and turrets having other characteristics

STODDART AIRCRAFT RADIO CO.
6644-B SANTA MONICA BLVD., HOLLYWOOD 38, CALIFORNIA
Hillside 9294

(Continued from page 32A)

amperes is available from Riverside Manufacturing and Electrical Supply Company, 10228 Michigan Avenue, Dearborn, Mich.

Illuminated Calibrated Scale Kit. A new Illuminated Calibrated Scale Kit for users of cathode-ray oscillographs has been announced by the Instrument Division, Allen B. Du Mont Laboratories, Inc. The kit, designated as type *2562*, facilitates amplitude and time calibration for both visual and photographic applications. The kit consists of four incandescent bayonet-type lamps with sockets, a bezel, front and rear masks, a plastic rectangular-co-ordinate calibrated scale, and a color filter. Further details may be secured by writing to the Allen B. Du Mont Laboratories, Inc., Instrument Division, 1500 Main Avenue, Clifton, N. J.

Cable Rack Series. The Adalet Manufacturing Company, Cleveland, Ohio, has announced an addition to its line of electrical conduit fittings. This is a series of phenolic insulating cable racks. The series is divided into two groups for 300 volts or under, or over 300 volts. The new cable rack series covers a complete range of types and sizes, including the delta arrangements. For more detailed information, write to the company at 14300 Lorain Avenue, Cleveland 11, Ohio.

Flowmeter. Accurate measurement of flow of liquids and gas under difficult conditions is made possible by the development of a new, improved flowmeter. The new unit is capable of handling toxic or highly corrosive substances, viscous liquids, or other fluids under pressures up to 20,000 pounds per square inch and temperatures ranging from −269 degrees centigrade to 1,200 degrees Fahrenheit. The meter was developed by Potter Aeronautical Company, improved in co-operation with Minneapolis-Honeywell's Industrial Division, and is marketed as the Potter-Brown flowmeter. The new device can be used for laboratory work as well as for industrial flow and automatic control applications. It is particularly adapted for use in the current development of petro-chemicals and hydrogenated coal-to-chemicals.

Subminiature Pentode. The Raytheon type *CK5889* is a subminiature pentode electrometer tube with a control grid current rating of 3×10^{-15} amperes maximum. Triode operating conditions are available also from published data. A minimum of filament power is required by the 1.25-volt 0.0075-ampere filament. The conducting ring around the bulb may be grounded through a connecting clip to provide complete isolation of the grid lead, which is at the top of the tube. Further information about *CK5889* may be obtained from Raytheon Manufacturing Company, Receiving Tube Division, 55 Chapel Street, Newton 58, Mass.

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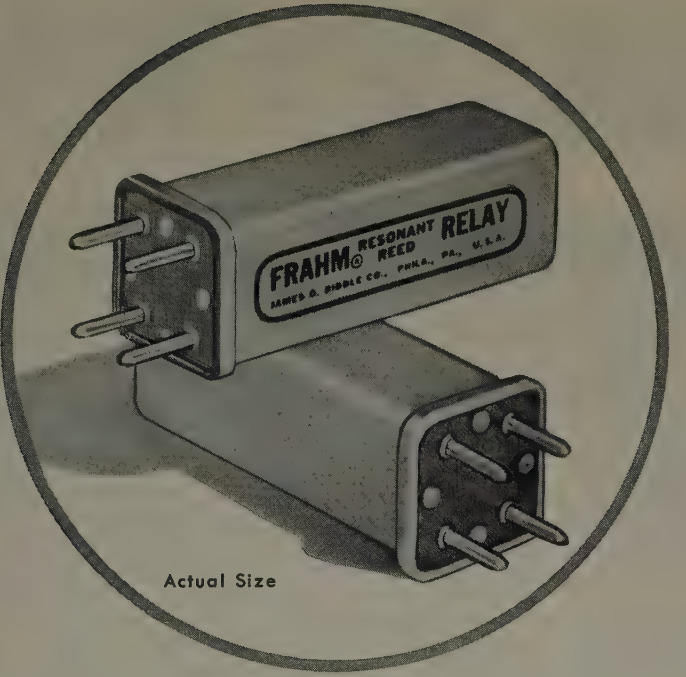
FRAHM® RESONANT REED RELAY
JAMES G. BIDDLE CO., PHILA., PA., U.S.A.
Actual Size

FRAHM® RESONANT REED RELAYS
OPEN NEW ERA TO ELECTRICAL DESIGNERS

The transmission of a number of control signals over a single circuit is greatly simplified by the use of these components. Their use is not limited to wire circuits but may be extended to all types of communication circuits including radio and carrier systems.

In a typical application a control function is used to turn on or off a source of low frequency signal (50-500 c.p.s.). The signal is transmitted either on a wire line or as a modulated carrier to some remote location where it operates a Reed Relay to indicate the control function at that point.

Since a given Reed Relay will only respond to a narrow band of frequencies, it is possible to operate a number of relays simultaneously by making use of an equal number of source generators arranged so that none of the operating frequency bands overlap.

In the range 200-500 cycles it is possible to operate up to 16 channels with no interference between channels.

Write for **BULLETIN 33-EE**

YOUR DESIGN ENGINEERING PROBLEM MAY BE SOLVED WITH FRAHM® RESONANT REED FREQUENCY METERS

Photograph Courtesy of Kaiser Aluminum and Chemical Corporation

At the Kaiser Aluminum and Chemical Corporation's Chalmette, Louisiana reduction plant (left) 80 control panels are equipped with flush mounted Frahm Frequency Meters to indicate the speed of the radial type Nordberg engines.

The ever-increasing variety of applications for which we are supplying these instruments reflects the versatility and adaptability of the vibrating reed principle, based on the phenomenon of resonance. The simplicity of Frahm Frequency Meters makes them sturdy and practically maintenance-free—a very important factor in today's economy. Specially designed Frahm instruments can be made to your specifications with modifications of range, method of actuating, scale graduations or other design characteristics for incorporation in your equipment. We invite your correspondence.

Write for **BULLETIN 32-EE**

JAMES G. BIDDLE CO.

- ELECTRICAL TESTING INSTRUMENTS
- SPEED MEASURING INSTRUMENTS
- LABORATORY & SCIENTIFIC EQUIPMENT

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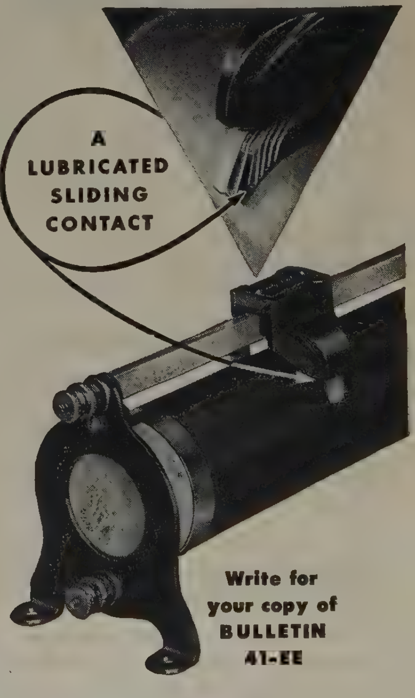
BIDDLE
Instrument News

"LUBRI-TACT" feature of JAGABI® RHEOSTATS insures precise, positive adjustment and long life.

Graphite-lubricated sliding contact with molded Bakelite saddle and laminated phosphor-bronze brushes. Solid-wall glazed porcelain tubes. Rugged one-piece supporting end-brackets. Strong, rigid, brass slider bar and strong binding posts. High insulation. Minimum inductance. Strong, durable design matched with expert manufacturing skill. Wound with standard resistance wire or strip. Available in standard types in 76 convenient ratings.



Write for your copy of BULLETIN 41-EE

James G. Biddle Co. B-831
1316 Arch St., Phila. 7, Pa.

Gentlemen:
Please send me material checked:

☐ 33-EE ☐ 32-EE ☐ 41-EE

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PECO

POWER for ELECTRONIC COMPUTERS

PECO Regulated Rectifiers
PEC 615 Series

For a reliable, accurate, regulated rectifier type power supply for powering the various sections of electronic computers, the Power Equipment Company has developed the PEC 615 series of units. Already installed and powering some of the larger computer installations in the country, these units have an extremely low maintenance program for equipment of this size.

For complete specifications, write for Bulletin No. 109 today.

SPECIAL FEATURES

- *Each power supply is insulated from ground so that either polarity may be grounded as required.*
- *Each power supply is equipped with a "high-low" protective system.*
- *All tubes used are operated at conservative ratings to provide long-life, with a minimum of maintenance.*
- *At the time of starting, the voltage is automatically applied and slowly raised to the operating condition to protect the tubes and condensers.*
- *Fuses are provided in each thyratron tube plate lead for maximum protection.*

PECO *Custom Built* REGULATED RECTIFIERS

To meet the requirements of closely regulated and filtered rectifier type power supplies, where the total amount of power is too great to be assembled into a single cabinet, Power Equipment Company is prepared to build equipments arranged for mounting on racks, and designed to generally conform with the customer's existing or proposed apparatus. For complete specifications, write for Bulletin No. 108.

POWER EQUIPMENT *Company*

55 ANTOINETTE STREET DETROIT 2, MICHIGAN

Battery Chargers ☆ Battery Eliminators ☆
D.C. Power Supply Units ☆ Regulated Exciters
☆ and other Special Communications Equipment

(*Continued from page 38A*)

Attenuator. Empire Devices, Inc., have announced their new laboratory standard ultrahigh-frequency attenuator, Model *AT-50*. This is a resistive T-network of concentric line construction, with a d-c frequency range up to 4,000 megacycles. The voltage standing wave ratio is better than 1.1 at all frequencies within the range. The standard attenuation is 3, 6, 10, 20, 40, and 60 decibels. The Model *AT-50* is accurate to ±1/2 decibel and the input and output impedance is 50 ohms. The rated power is 250 megawatts continuous, 500 watts peak dissipation.

Utility Picture Monitor. Federal Telecommunication Laboratories, Inc., Nutley, N. J., has announced a new low-cost Utility Picture Monitor for television station applications. Designated as the *FTL-P-91B*, the monitor is available either rack or cabinet mounted. A high-quality high-resolution 9- by 12-inch presentation is made on a *16GP4* kinescope. A removable front panel is incorporated for cleaning the kinescope face and the protective safety glass. Controls are contained on a recessed section of the front panel. Duplicate coaxial input connectors with a switch to select composite video, or separate video and composite sync, are provided at the rear of the chassis. A self-contained, fused power supply is included.

Instrument Panel Vibrator. Globe Industries, Inc., Dayton, Ohio, has developed an instrument panel vibrator. The panel vibrator is designed to introduce a vibration of known frequency and amplitude into instrument panels to increase meter accuracy and prevent sticking. The vibrator is an electrically driven device operating continuously. Motor power for the vibrator is furnished by a fractional-horsepower motor operating at any standard direct voltage. The motor is a 2-pole 2-brush design. An unbalanced weight is mounted on the end of the armature shaft. Weight provides the vibration action of the assembly. Shaking forces, at 2,500 rpm, can be provided from 0.85 to 3.4 pounds by varying the weight. The frequency is 2,000 to 3,000 cycles.

Shockproof Meters. The Hickok Electrical Company, Cleveland, Ohio, has announced a new line of d-c and rectifier-type a-c meters. Shock mounted in a special low-temperature rubber compound and bonded to the case, the meter movement is rigidly held and does not flop around under vibration or shock and permits pointer and scale divisions to be read easily when meter is under vibration. Types available are d-c and a-c microammeters, milliammeters, and voltmeters, and d-c ammeters. Complete information is available on request to the Hickok Electrical Instrument Company, 10515 Dupont Avenue, Cleveland, Ohio.

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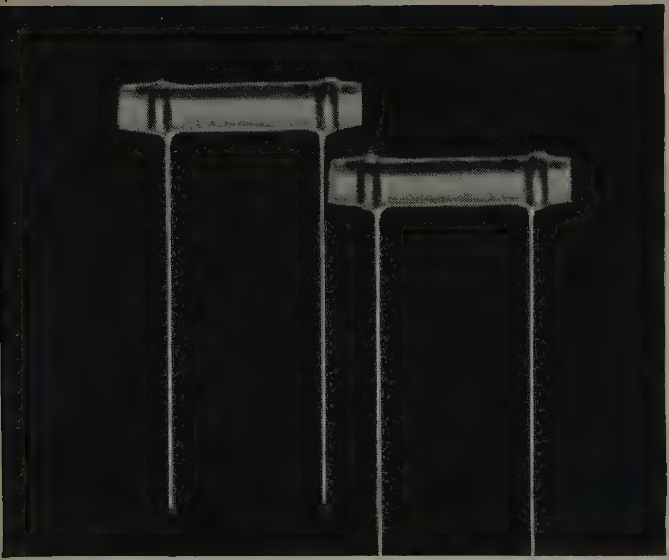
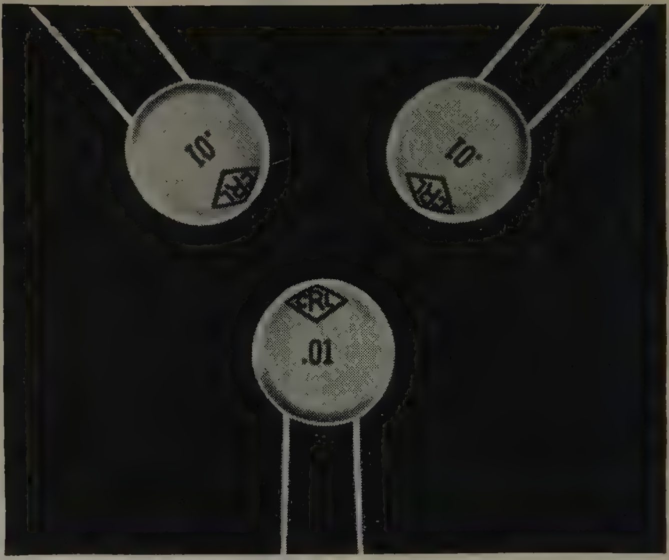
NEW CRL HI-KAPS..



BC HI-KAP TUBULAR CERAMIC CAPACITORS — new D16 offers 1600 vdcw, 3000 vdct; D30 — 3000 vdcw, 6000 vdct. Ideal for use in r.f. by-pass and audio-coupling applications.



CERAMIC DISC HI-KAP "BUFFER" CAPACITORS — new DD16 offers 1600 vdcw, 3000 vdct. Minimum thickness, very high capacity in extremely small size. Also used in HF by-pass and coupling.

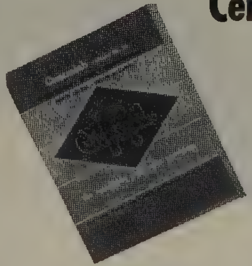
...give you benefits of low-cost ceramic capacitor construction in 1600V and 3000V range

FIRST to introduce ceramic Hi-Kap Capacitors to the electronic industry, now Centralab is first to extend the advantages of ceramic construction to still higher voltages. Tubular type by-pass couplings are now available in 1600 and 3000 vdcw. In addition, a new disc type Hi-Kap is available for the 1600 vdcw range. And what's more, *they cost less than ordinary paper or mica capacitors of similar rating.*

They're more dependable, too. Far superior to old-style capacitors. That's because ceramic construction resists moisture and humidity. *(Absorption is only 0.007% or less.)* Ceramics withstand heat, too . . . as much as 85° C.—higher than any temperature normally encountered in electrical apparatus. Vibration is no problem.

Electronic engineers — look to your designs now. You're sure to find a place for these new, higher voltage Hi-Kaps. Ask your distributor for further information — or use the coupon.

Centralab's New Catalog 28



Just off the press and ready to keep you up-to-date on the fast-changing electronics picture. Over 470 new components pictured and described.

Centralab

A Division of Globe-Union Inc. • Milwaukee 1, Wis.

CENTRALAB, A Division of Globe-Union Inc.
932 East Keefe Avenue, Milwaukee 1, Wisconsin

Please send me the technical bulletins on ceramic capacitors D16, D30 and DD16 and/or Catalog 28 as checked:

☐ Bulletins ☐ Catalog 28

Name..

Address..

Company..Title........................

unit substations

switchgear
(drawout or stationary)

panelboards

feeder & plug-in bus duct

"Concentrol" motor control centers

instrument panels

"Weather-Loc" enclosures

theater switchboards

wireway

. . . the modern, safe, centralized motor control with "Concentrol" positive-pressure plug-in to bus. Furnished with your choice of control equipment. Save space, cut maintenance, keep production rolling . . . at lower installed cost. Make future layout and operation changes easy. And, Continental deliveries are good!

Send for new descriptive "Concentrol" Bulletin No. 400

Before you decide on any Electrical Distribution Equipment, be sure you have Continental's engineered proposals and delivery schedules! Your inquiries will be given prompt attention . . . and Continental's standardized equipment will get you into action . . . fast!

CONTINENTAL
ELECTRIC EQUIPMENT CO.
BOX 1055-E, CINCINNATI 1, OHIO

. . . manufacturers of one of the most complete lines of Electrical Distribution Equipment

Specify Continental . . . with Confidence!

(Continued from page 52A)

Aluminum Clamp. The introduction of an aluminum-body tap clamp that can be used for aluminum-to-copper, aluminum-to-aluminum, copper-to-aluminum, or copper-to-copper connections has been announced by the A. B. Chance Company, Centralia, Mo. The Chance Company states that exhaustive research and testing has proved that plating an aluminum-body clamp to a specified thickness with fortified cadmium solves the problem of general-purpose connections in most applications. Complete data will be supplied by the manufacturer.

Ceramic Capacitors. A line of disk-type ceramic capacitors is being offered to the radio and television industry by Allen-Bradley Company, Milwaukee, Wis. The new line of capacitors ranges from 0.001 to 0.01 microfarad. The basic element of the capacitor is a ceramic disk of high K dielectric which is molded and sintered. A deposit of silver paste then is applied to each face of the disk and heat treated to reduce the paste to metallic silver. Leads are soldered to the silver surfaces and the entire capacitor is insulated with phenolic resin. The unit is then wax impregnated to resist moisture.

Test Clip. Completely insulated, the new Grayhill Alligator-Type Test Clip, known as the Series Number *16* Clip, can be used freely side by side without danger of short-circuiting. This new clip is said to offer also such features as silver contacts for low-contact resistance, brass current-carrying members silver soldered for easy soldering of the lead, and positive spring action for good contact. Complete information may be had by writing to B. Doran, Grayhill, 4524 West Madison Street, Chicago, Ill.

Torque Motor. Midwestern Geophysical Laboratory, Tulsa, Okla., has announced its Model *9* Torque Motor. It is described as a precision linear actuator primarily designed to stroke pistons in hydraulic servovalves. It is being utilized in many engineering fields as a basic transducer to convert a few watts of power from an electronic amplifier to a linear mechanical motion with considerable force. Midwestern has supplied the following specifications: midposition force, 9.5 pounds; stroke ±.015 inch; weight, 19 ounces; no-load natural frequency, 425 cycles per second; coil resistance, 3,400 ohms each; and balance current, 20 milliamperes.

Ignitron. National Electronics, Inc., Geneva, Ill., have announced the addition of a new ignitron to their line of industrial tubes. This ignitron, designated as the *NL-5822,* is a metal water-cooled mercury-pool tube designed especially for frequency-changer resistance welders. *NL-5822* utilizes an all-copper cooling system that provides exceptional cooling efficiency.

(Continued on page 64A)

A Glance tells you it's Overloaded

Read How the *Thermalite* Indicator Can Save You Money in Transformer Protection and Utilization in Any Season . . . for Any Climate

WHEN THE BRILLIANT SIGNAL LIGHT of the *Thermalite* overload indicator flashes on, you can tell — at a glance — that your distribution transformer is overloaded. There is no interruption of service. Timesaving visual detection like this can save you hundreds of man-hours on costly surveys. It will help to eliminate transformer burnouts and service interruptions.

Important Advantages Save Money

Simple in operation . . . the warning light is actuated by a thermal device in the top oil. The light snaps on during excessive overload periods and remains on until turned off by an external handle.

The *Thermalite* indicator will stretch the dollars you spend for transformer protection. It's low in original cost, dependable and requires no maintenance. It is engineered, calibrated and installed at the factory.

Learn more about this visual, inexpensive way of detecting transformer overloads by calling your nearby A-C sales representative or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-3793

Thermalite is an Allis-Chalmers trademark.

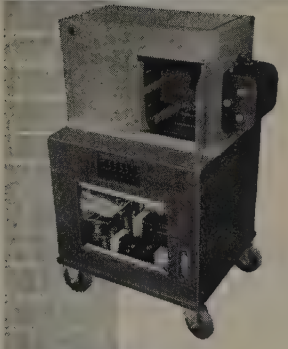
The Thermalite overload indicator is available on distribution transformers 100 kva and smaller, 15 kv and below.

ALLIS-CHALMERS A-C ALLIS CHALMERS

No more worries about
FREQUENCY RESPONSE
or
WRITING SPEED.

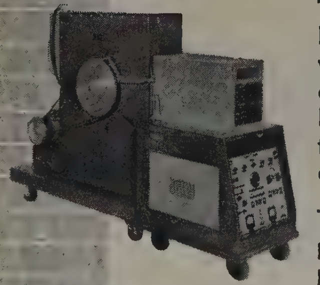
The NEW and PHENOMENAL

HATHAWAY Type SC-16
OSCILLOGRAPH
with 6 elements is *flat from*
0 to 200,000 cycles per second, and its traces
have a *writing speed of 5 million inches per second.*



Fast transients and high-frequency phenomena now can be accurately recorded.

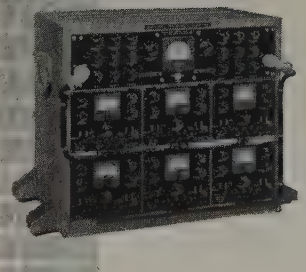
Several types of continuous-drive record magazines are available for 6-inch sensitized paper and film, and for 35-mm film. The magazine shown on the oscillograph at the left accommodates 100-foot rolls of record paper.



Drum-type magazines, both small and large, are valuable for short high-speed records. The large drum-type magazine at the left has a drum 3 feet in diameter and 6-inches wide. It can be driven at 3000 RPM for a *chart speed of 6000 inches per second* when high resolution is needed. It can be used to take one 10-foot record or a larger number of shorter records.

The ASC-10 6-element direct-coupled amplifier will drive the SC-16 oscillograph from potentials of millivolt level.

Useful for strain recording to 100 Kilocycles.



AUTOMATIC OPERATION Initiate a transient with the oscillograph, or let the transient start the oscillograph.

QUICK-CHANGE TRANSMISSION for wide range of record speeds.

PRECISION TIME LINES.

Z-AXIS MODULATION for timing to one-tenth millisecond.

QUICKLY-INTERCHANGEABLE LENS STAGES for different record and trace widths.

Write for Bulletin 2G1M for details

Write for FREE copy of Hathaway Engineering News

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

(*Continued from page 56A*)

The mercury-pool cathode permits the tube to handle extremely high currents on an intermittent basis. The baffle construction reduces deionization time and permits satisfactory operation under severe conditions of commutation.

Heavy-Duty Cutouts. New heavy-duty cutouts, rated 5.2 kv, 100 and 200 amperes, with higher interrupting ratings have been announced by the General Electric Company's Distribution Transformer Department. These new cutouts will interrupt short-circuit currents of 8,000 amperes at 5 kv and 12,000 amperes at 2.5 kv. Interrupting ratings of the superseded cutouts were 8,000 amperes at 5 kv and 5,000 amperes at 2.5 kv. The new 100-ampere heavy-duty cutout can be distinguished from the standard-duty cutout by the reflector on the cutout door. Day or night, this reflector is visible from the ground.

Pneumatic Closing Mechanism. A new pneumatic closing mechanism for power circuit breakers is available from the Westinghouse Electric Corporation. More powerful than a solenoid mechanism, the pneumatic device provides the increased energy required in the quick closing and reclosing of circuit breakers of high interrupting capacity. Two sizes of mechanism are available: the type *AA-7* and the *AA-10* with 7- and 10-inch pistons, respectively. These two mechanisms are used for closing circuit breakers ranging from 14.4 kv, 500,000 kva, through 230 kv, 15,000,000 kva. High-speed reclosing in 20 cycles, ultrahigh-speed reclosing in 15 cycles or less, or multiple high-speed reclosing is possible. The air compressor is driven by a single-phase motor and can charge the reservoir tank with enough air for five operations. For further information, write Westinghouse Electric Corporation, Box 2099, Pittsburgh, Pa.

TRADE LITERATURE

Centrifugal Refrigeration Drives. E-M Synchronizer Number 36 of the Electric Machinery Manufacturing Company deals with the application of a-c motors to centrifugal refrigeration compressors. Refrigeration characteristics, compressor capacity control, motor characteristics, and motor control are discussed. This 24-page booklet is fully illustrated and includes a number of charts and tables of helpful engineering information. It is available on request from Electric Machinery Manufacturing Company, Minneapolis, Minn.

Paper Tubing. A recently published Arbor List of over 1,500 sizes of paper tubing is available from the Precision

(*Continued on page 66A*)

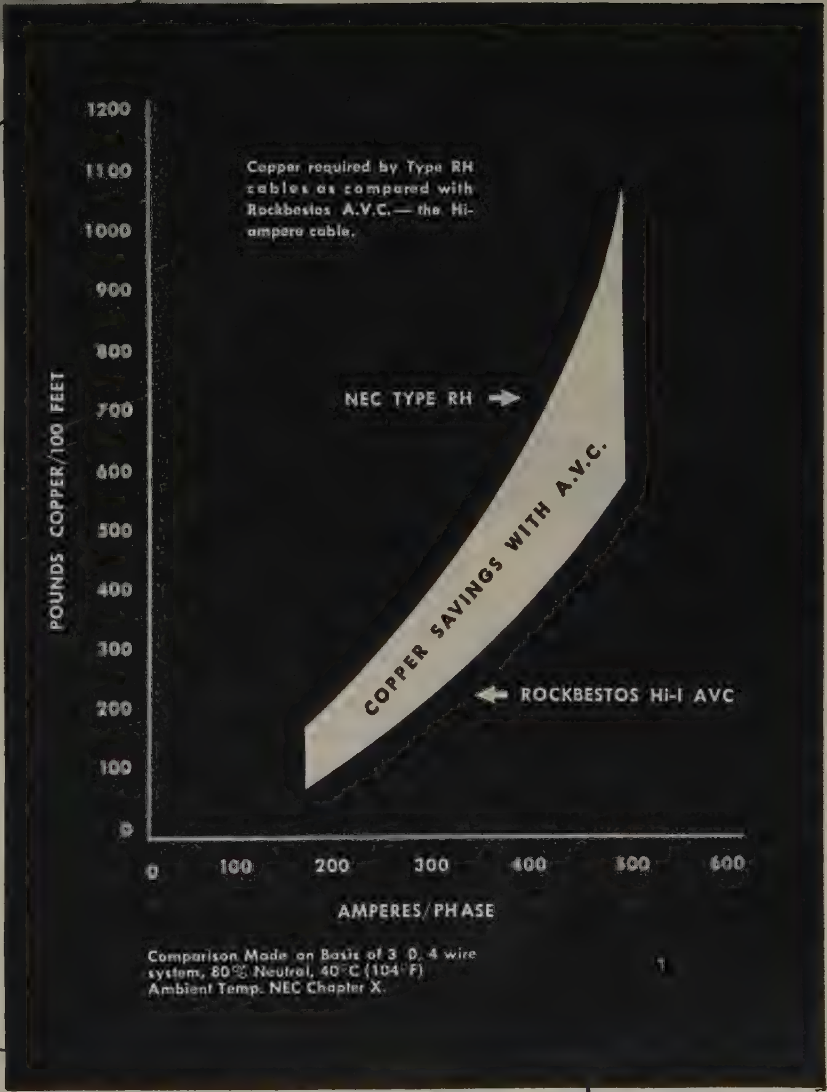
HERE'S PROOF

1 lb. of copper will
do the work of 1.6 lbs.
when you use

Hi I $I=\frac{E}{R}$
Your best buy

ROCKBESTOS A.V.C.®

(CODE TYPE AVA)



Comparison Made on Basis of 3 Ø, 4 wire system, 80% Neutral, 40°C (104°F) Ambient Temp. NEC Chapter X.

Size for size Rockbestos A. V. C. carries more current than ordinary cables. And that's why it makes your critical copper and steel go farther.

You always use a smaller cable with Rockbestos A.V.C. Smaller cable requires *less* copper and smaller conduits and fittings on your power circuits. You save copper — save steel — save time and money.

Where voltage drop and power losses are critical, proper engineering allowances should be made.

Call your Rockbestos Application Engineer *today.* Ask for a copy of "Rx for a Building with Hardening of the Arteries."

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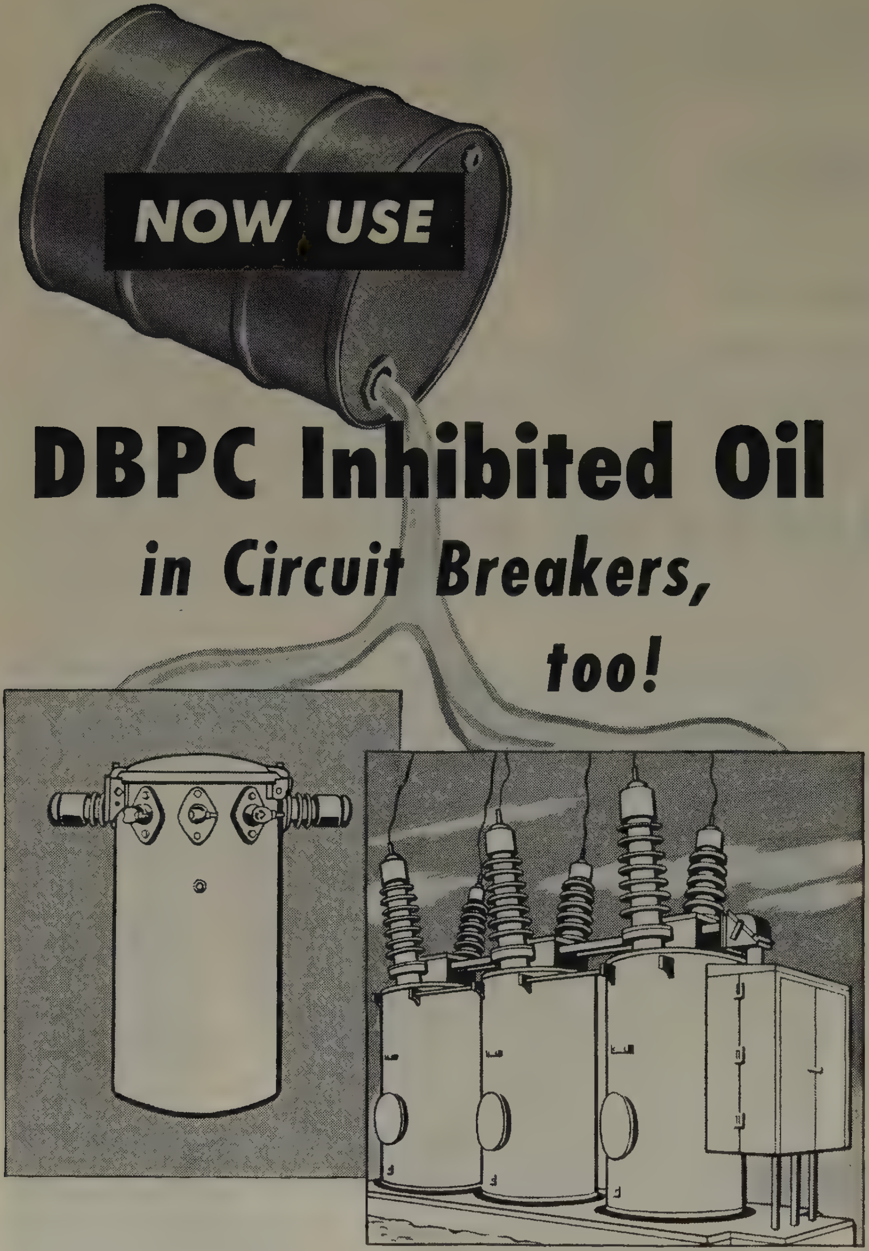
NEW YORK CLEVELAND DETROIT CHICAGO PITTSBURGH
ST. LOUIS LOS ANGELES OAKLAND, CALIF. NEW ORLEANS



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DBPC Inhibited Oil in Circuit Breakers, too!

When DBPC (Di-tert-butyl-para-cresol) is added to transformer insulating oils, their resistance to oxidation is increased and their useful life is greatly extended. The value of Koppers DBPC as an inhibitor for new or reclaimed oil has long been proved.

Now, it has been shown that DBPC-inhibited oil can also be used in circuit breakers. The oxidation inhibitor, DBPC, does not affect arcing time, rate of gas generation, rate of carbon formation, rate of carbon settling or rate of dielectric change.

For longer oil life, for greater resistance to oxidation . . . specify Koppers DBPC. It can be used in both transformers and circuit breakers and thus, simplifies inventory problems.

Most suppliers furnish DBPC inhibited oil on request. For your convenience we can supply a compounded oil solution of DBPC called Impruvol 20. The application of Impruvol 20 is as simple as the application of the insulating oil itself. Write for more information on use of DBPC inhibited oil in transformers and circuit breakers.

KOPPERS ®

KOPPERS COMPANY, INC.
Chemical Division, Dept. EE-112
Pittsburgh 19, Pa.

(*Continued from page 64A*)

Paper Tube Company, Chicago, Ill., and Hartford, Conn. This 16-page catalogue listing contains informative data and specifications on square, rectangular, and round tubing. Tubes are furnished in a variety of spirally-wrapped dielectric papers. For further information write to Precision Paper Tube Company, 2035 West Charleston Street, Chicago, Ill.

Potheads and Terminals. The Anaconda Wire and Cable Company has published a catalogue on potheads and terminals which comprises Section 13 of their General Catalogue. The new catalogue, *C79-13*, includes complete design data as well as information and instructions valuable for proper ordering and installing all types up to 46 kv. It features both outdoor and indoor types and popular designs for transformers and switchgear and illustrates such desirable features as simplicity, interchangeability, and reliability. This publication, as an individual catalogue, or the General Catalogue incorporating Section 13, is available by addressing a letterhead to E. F. Luna, Sales Promotion Director, Anaconda Wire and Cable Company, 25 Broadway, New York, N. Y.

Bushings and Terminal Assemblies. A comprehensive catalogue incorporating full technical descriptions and dimensional diagrams of their complete line of hermetic seal bushings has been announced by the Heldor Terminal and Bushing Company, Inc., 225 Belleville Avenue, Bloomfield, N. J. This 40-page catalogue features, in addition to bushings and terminal assemblies, technical data on studs, washers, steatite, convoluted steatite, and glands. Copies may be secured by writing to Heldor's advertising department.

Bronze Bearings. A complete presentation of the products and services of the Bunting Brass and Bronze Company is contained in its latest catalogue. New sizes have been added to the lists of Bunting Bronze Bearings and Bunting Precision Bronze Bars. There are 854 different sizes of standard stock bearings, 324 different electric motor bearings, and 263 sizes of tubular and solid bronze bars included in the catalogue. Copies are available from the Bunting Brass and Bronze Company, 715 Spencer Street, Toledo, Ohio.

Electrical Wires and Cables. The electrical wire and cable department, United States Rubber Company, has published a 186-page general catalogue of its line of more than 500 different types of wires and cables. The catalogue contains comprehensive data on construction and

(*Continued on page 68A*)

Let's talk turkey

about steel wire

● If you can't get all the steel wire you need, we may be able to help you do a satisfactory job.

Here's how: At one time or another, our skilled metallurgists have tackled just about every conceivable problem in steel wire fabrication. We often find manufacturers who specify a wire that is unsuitable for the job it has to do. In many of these cases we've been able to study the problem and come up with an answer that means improved fabricating techniques that lower production costs.

Sometimes we can suggest a slight *design* change that will save a lot more wire than you ever thought possible.

So take advantage of this free consultation service. It's nothing new. We've always offered it. But today, you may need it more than ever before.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL COMPANY
GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

AMERFINE—*High-quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire.*

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MANUFACTURERS WIRE

USS TRADE MARK

UNITED STATES STEEL

CONVENIENCE IN OPERATION—
A 60-watt transmitter, receiver, power supply, and controls—in a single unit for desk-top operation. Available in 30-50 mc range, 152-174 mc range.

CONVENIENCE IN MAINTENANCE—
Chassis slides up for complete accessibility. Cabinet acts as handy, solid servicing rack. No need to remove chassis from cabinet.

NOW see what CONVENIENCE means
with RCA's new 2-way radio station

CONVENIENT!
Compact, space-saving design
Complete base station in a single desk-top unit using less than 3½ square feet of desk space—saves valuable floor space.

CONVENIENT!
Up to 3 transmitter channels, 2 receiver channels
Designed for up to 3-channel transmission and 2-channel reception where required. Lights on front panel indicate frequency in use.

CONVENIENT!
Easy to install and service
Just plug in transmission line and AC power and you are ready to operate. Lift-out chassis for servicing in cabinet. Metering plugs for easy checking.

CONVENIENT!
Local or remote operation
Choice of local or remote control base station in single, compact cabinet. Chassis also available in standard cabinet rack or weatherproof, pole-mounting box.

For further details on the new RCA 60-watt desk station, MAIL COUPON NOW

Dept. 42K, RCA Engineering Products,
Camden, New Jersey

( ) Please send me information on new Carfone desk station.

Also send me information on 2-Way Radio for:
( ) General Industry (Utilities, Construction, Petroleum, Lumber, Mining, etc.)
( ) Transportation (Trucks, Buses, Taxis) ( ) Public Safety (Police, Fire, Ranger)

Name__________
Title__________
Organization__________
Address__________
City________Zone____State______

RADIO CORPORATION of AMERICA
MOBILE COMMUNICATIONS CAMDEN, N. J.

(*Continued from page 66A*)

operating characteristics for such products as control and signal cables, railroad wire and cables, wire and cables for the building industry, telephone wire and cables, mine cables, and portable cords. A detailed technical engineering data section is included. Copies may be obtained from R. H. Turner, United States Rubber Company, Rockefeller Center, New York, N. Y.

Precision Test Equipment. Polytechnic Research and Development Company, Inc., Brooklyn, N. Y., has announced the latest edition of its catalogue of precision test equipment. The catalogue includes sections on attenuators and terminations, impedance measurement and transformation, transmission line components, frequency measuring devices, detection and power measurement, signal sources and receivers, and very-high-frequency–ultra-high-frequency test equipment. Charts and illustrations are included.

200 Fluid Silicones. Dow Corning 200 Fluid silicones are described in a booklet released by the company. Over 20 different properties of these versatile fluids, from boiling point to sound transmission, are discussed and illustrated. References are given and a blending chart for intermediate viscosities is included. Current industrial applications, such as use as a defoamer and polish ingredient, a release agent and a dielectric, a damping medium and a paint additive, are pictured and described. Copies are available upon request to Dow Corning Corporation, Midland, Mich.

Electrode Bulletin. A new, 49-page pocket-size booklet describing the application, chemical analysis, and mechanical properties of General Electric welding electrodes has been announced as available from General Electric Welding Distributors. Designated *GED-1634*, the new booklet also includes an electrode trouble-shooting chart which specifies the number of electrodes per pound, and an explanation of the significance of the American Welding Society nomenclature.

Industrial Motor Controls. A new motor controls catalogue has been announced by The Arrow-Hart and Hegeman Electric Company, Hartford, Conn. Easy-preference propaganda sections, weights and dimensions sections, and ordering sheets are supplied on the complete Arrow-Hart line of advanced type "*RA*" motor controls, comprising magnetic starters, multispeed and reversing starters, magnetic contactors, and reversing contactors. Full ordering information is included on the Arrow-Hart line of manual starters, pushbutton stations and interchangeable control units, midget relays, limit switches, and push-pull selector switches. For a copy of the catalogue write to Industrial Control Division, The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn.

(*Continued on page 70A*)

American Standard
LETTER SYMBOLS
for
ELECTRICAL
QUANTITIES

This American Standard (Z10.5—June 1949), which has been prepared by a subcommittee of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering, is a revision of ASA Z10gl and AIEE 17gl.

General principles of letter symbol standardization, a typographical notation for distinguishing, in the equations of the printed page, between the symbols for scalar, complex (phasor), and vector quantities are given, as well as tabulations of the symbols in alphabetical order of the names of quantities, English letter symbols, and Greek letter symbols.

Price: $0.60; there is a 50 per cent discount for AIEE members.

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33 West 39th Street
New York 18, N. Y.

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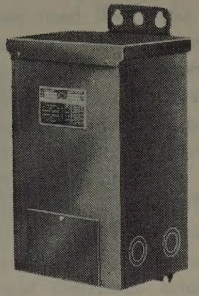

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3 KVA to 15KVA inclusive. Modern design for quick, neat installations. Light weight. Air cooled.

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25 KVA to 200 KVA inclusive. Extra large junction box speeds hook-up.

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A photo record is quicker, more accurate; and it may prove to be priceless.

THE ADVANCED single-lens reflex design of the 35-mm. PRAKTICA FX makes it easier for you to get expert photomicrographs, oscillographs, extreme close-ups, copy work, etc., in black and white or natural color. Use it for: Recording lab and field observations, quality control, inspections, photographing equipment in field, training personnel, etc. Excellent for the home photographer, too. From $99.50 to $199.50 (tax incl.).

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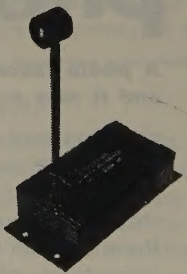
When you gamble on weak or defective insulation for motor and generator repairs, high labor costs will beat you every time. If you want to keep motors and generators in service longer and slash repair costs, then National's premium-quality insulation is a sure winner. Stop taking needless chances. Make National insulating materials a must for every motor repair job. They've been developed by National engineers for use in National's own shops. That's your guarantee of long life and consistent high quality.

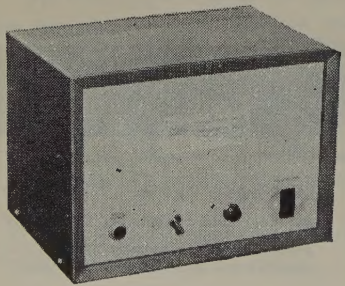
National offers a complete line of standard insulation, stands ready to supply special shapes and other non-standard items to your specifications. Order from National — you'll get just the insulation you need and you'll get it *fast*.

Visit us at Booth 1327, Plant Maintenance Show, Cleveland, January 19-22.

NATIONAL ELECTRIC COIL COMPANY
COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES





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Thermistor bolometers are FAST, sensitive INFRARED and HEAT detectors. Especially RUGGED for industrial, scientific, and military applications. PREAMPLIFIER provides NOISE-FREE initial amplification and mount.

THERMISTOR POWER SUPPLY

Provides voltages required by BOLOMETER bridge and PREAMPLIFIER. Regulated and filtered permitting THEORETICAL NOISE LIMITS of amplification, while operating from 60 CYCLE line.

SERVO CORPORATION OF AMERICA

DEPT. EE-11 NEW HYDE PARK, N.Y.

(*Continued from page 68A*)

Electric Wiring. Over 1,400 electric wiring devices are included in the 48-page catalogue issued by Eagle Electric Manufacturing Company, Inc., 23–10 Bridge Plaza South, Long Island City 1, N. Y. Illustrated with full information, this new catalogue is designed to serve as a selling device as well as a reference book for the trade. All products are cross-indexed to facilitate quick and easy finding. It is available upon request to the company.

Pressed Brass. Basic design principles and new information on mechanical properties are combined with an analysis of cost and production factors in the New Jersey Zinc Company's 32-page manual "Facts About Pressed Brass and Other Nonferrous Powder Parts." Written primarily for designers, engineers, and metallurgists, the new handbook is intended to be a concise reference to the factors which should be considered in designing and selecting small structural parts for fabrication by the powder metallurgy method. Illustrating the booklet are drawings, prints, and photographs of parts. Copies of the manual may be obtained by sending requests, on a company letterhead, to The New Jersey Zinc Company, Front and Fletcher Streets, New York 38, N. Y.

Switch Catalogue. A 24-page 2-color catalogue, Number *82*, of precision snap-action switches has been published by Micro, Freeport, Ill., a division of Minneapolis-Honeywell Regulator Company. This catalogue covers safety, limit, and interlock switches designed especially for switching a-c circuits in industrial and commercial applications. The catalogue covers heavy-duty precision limit switches, switches enclosed in metal housings, some of which are sealed against the entrance of dust, dirt, and sealed against the splash of oil, water, and similar fluids harmful to switch mechanisms. Other products included in the catalogue are explosion-proof switches, splashproof switches, auxiliary brackets and switch-actuators, standard size basic switches, and the ultrasmall switch designs.

Meter Relays. Simplytrol contact meter relays are described in a 21-page booklet released by Assembly Products, Inc., Chagrin Falls, Ohio. It includes a general description of the instrument with circuit diagrams and lists of components for the circuits shown. The booklet will be supplied with each new contact meter. It is offered also to present users and to others who are interested in learning more about these new control meters.

Catalogue of Crystals. A complete catalogue of crystals has been issued by the James Knights Company of Sandwich, Ill. The new catalogue lists 45 different crystals for use in communications equipment, laboratory instruments, medical and industrial equipment. Copies may be obtained by writing James Knights Company, Sandwich, Ill.